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REQUIREMENTS STUDY FOR A BIOTECHNOLOGY LABORATORY FOR MANNED EARTH ORBITING MISSIONS

Volume II - Summary of Individual Experiments Requirements

by L. T. Kail

Prepared by
MCDONNELL DOUGLAS CORPORATION
Huntington Beach, Calif.
for

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PREFACE

This document is part of the final report of a study of requirements for a biotechnology laboratory for manned earth orbiting mission. The study was conducted by the McDonnell Douglas Astronautics Company—Western Division, (MDAC—WD) at its Space Systems Center in Huntington Beach, California, for the Biotechnology and Human Research Division of the Office of Advanced Research and Technology (OART) at the National Aeronautics and Space Administration (NASA) Headquarters, Washington, D. C. The work was performed in accordance with contract no. NAS7-518.

The report is presented in two volumes. Volume I describes the main results of the study, including the research program definition, requirements, and recommendations. This volume summarizes the requirements of individual experiments.

The work on this study was performed by MDAC--WD personnel from two departments: Advance Biotechnology and Power Systems, Dr. K. H. Houghton, Chief Engineer, and Advance Space Stations, F. C. Runge, Program Manager. The study was managed for NASA (OART) by R. W. Dunning (RBB) and MDAC--WD by L. T. Kail, Branch Manager, Advance Space and Launch Systems.

Throughout the contract, the MDAC--WD study team maintained close coordination with NASA Headquarters personnel. The study-team members and their NASA coordinators were:

Study Team	NASA Coordinator
Bioscience - Dr. W. H. Lawrence, Jr.	Donn K. Jenkins (SB)
Biomedicine - Dr. W. F. Arndt, Jr.	Dr. E. J. McLaughlin (MM)
Behavior - J. D. Brower	Dr. S. Deutsch (RBM)
Life Support Systems - T. C. Secord	A. L. Inglefinger (RBB)

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EXPERIMENT REQUIREMENTS SUMMARY

This volume summarizes the requirements of each experiment used in establishing the biotechnology requirements described in Volume 1 of this report. The requirements for each experiment are presented in four sections:

1. Biomedical and Human Research.
2. Behavioral Research.
3. Bioscience Research.
4. Life Support and Protective Systems.

The experiment title, category, and assigned number relate directly to the research program discussed in Volume 1, Section 2.

The entry under the item entitled, PERSONNEL REQUIRED, refers to the type and number of individuals required to perform the MEASUREMENTS AND OBSERVATIONS.

In the Biomedical and Human Research section, the EXPERIMENT DURATION indicates the time required to perform the measurements on <u>one</u> human subject. In those experiments involving animals, the time given is for <u>all</u> the subjects.

In the Bioscience Research section, specific experiment task times could not be estimated because this information will be dependent upon the degree of automation required by the various equipment. For this reason, then, the title of this item in this group of experiments has been changed to read, DESIRED MISSION DURATION.

BIOMEDICAL AND HUMAN RESEARCH
EXPERIMENT LIST

1-1 Effect of Head Movement during Rotation
1-2 Sensitivity of Otolith and Semicircular Canal Mechanisms
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1-55 Immunological Survey of Crew Members

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-1

Effect of Head Movement during Rotation

EXPERIMENT CATEGORY

Neurological Function--Vestibular Function in Space

OBJECTIVE AND SIGNIFICANCE

To determine the thresholds and tolerance to visual illusions produced by head movements in a rotating environment during weightlessness. Results are needed for correlation with ground-based experiments and to establish permissible vehicle rotation rates for defining design requirements of future spacecraft.

MEASUREMENTS AND OBSERVATIONS

Oculogyric illusion
Nystagmus
Task performance (visual)
Egocentric visual localization of the horizontal
Electroencephalography (EEG)

EXPERIMENT DURATION

60 min. every other day for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

4 crew members
Phoropter
Tilting motion chair
Vision test target with horizon reference line
Cine camera and fiber optics
Electroencephalograph
Nystagmographic goggles

SPECIAL REQUIREMENTS/REMARKS

Performance measuring equipment is required to assess specific tasks requiring head motion and hand dexterity. EEG monitoring is recommended for the assessment of behavior and performance parameters. Short-radius centrifuge is desirable to extend observations beyond those initially suggested in references and to make results more comparable to ground-test data.

PERSONNEL REQUIRED

1 technician

REFERENCES

Apollo Extension Systems Experiment List. National Aeronautics and Space Administration (NASA), Washington, D. C., 15 March 1965.

S. P. Vinograd, Medical Aspects of an Orbiting Research Laboratory. Space Medicine Advisory Group Study, NASA Report No. SP-86, 1966.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-2

Sensitivity of Otolith and Semicircular Canal Mechanisms

EXPERIMENT CATEGORY

Neurological Function--Vestibular Function in Space

OBJECTIVE AND SIGNIFICANCE

To measure the sensitivity and interaction of semicircular canal and otolith functions and their changes during prolonged weightlessness. Results will be used in developing countermeasures to prevent the vestibular function from lowering astronaut efficiency in flight and post-flight.

MEASUREMENTS AND OBSERVATIONS

Ocular counter-rolling
Oculogyric illusion
Oculogravic illusion
Task performance
Egocentric visual localization of the horizontal
Eye-muscle balance
Electroencephalography (EEG)

EXPERIMENT DURATION

60 min. every 3 days for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

4 crew members (2 as a minimum)
Nystagmographic Goggles
Phoropter
Tilting motion chair
Vision test target with horizon reference line
Cine camera and fiber optics
Behavioral test equipment
Electroencephalograph

SPECIAL REQUIREMENTS/REMARKS

All parameters should be monitored against EEG signals to access vestibular function as a concomitant of behavioral performance. Short-radius centrifuge is desirable to make results more comparable with ground-test data.

PERSONNEL REQUIRED

1 technician

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D.C. 15 March 1965.

Feasibility Study of a Centrifuge Experiment for the Apollo Application Program, NASA RFP L-7631.

S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-3

Effect of Altered Day-Night Cycles on Mating Behavior and Litter Size of Rats, and on EEG of Cats

EXPERIMENT CATEGORY

Neurological Function--Animal Research

OBJECTIVE AND SIGNIFICANCE

To determine the effect of various combinations of day-night cycles on mating behavior and litter size of rats, and on EEG of cats. In many mammals, light influences pituitary-gonadal functioning.

MEASUREMENTS AND OBSERVATIONS

Task performance
Electroencephalography (EEG)
Temperature

EXPERIMENT DURATION

5 min. daily for first week; then, 30 min. weekly for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

6 rats (3 male, 3 female) and 2 cats
Electroencephalograph
Temperature recorder
Cine camera

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

1 technician

REFERENCES

Originated by MDAC.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENTAL TITLE — TEXT REF. NO. 1-4

Resting Discharge of Vestibular Receptor Cells in Primates during Physiologic Deafferentation of Otoliths (Weightlessness)

EXPERIMENT CATEGORY

Neurological Function--Animal Research

OBJECTIVE AND SIGNIFICANCE

To determine whether complete deafferentation of otoliths results in irreversible pathological changes in the vestibular receptor cells.

MEASUREMENTS AND OBSERVATIONS

Electroencephalography (EEG)
Electrical discharge of vestibular receptor cells

EXPERIMENT DURATION

30 min. daily for first 2 weeks; then, 30 min. twice weekly for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 monkeys (rhesus or spider)
Oscilloscope and photographic recorder
Electroencephalograph

SPECIAL REQUIREMENTS/REMARKS

Comparison of results for restrained and freely moving animals is required. Electrodes are implanted in animals prior to mission.

PERSONNEL REQUIRED

2 technicians

REFERENCES

S. P. Vinograd, Medical Aspects of an Oribiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-5

Changes in Circulatory Response to Exercise

EXPERIMENT CATEGORY

Cardiovascular Function--Cardiovascular Deconditioning

OBJECTIVE AND SIGNIFICANCE

To determine circulatory integrity, with emphasis on the heart's ability to respond to stressful situations under prolonged weightlessness.

MEASUREMENTS AND OBSERVATIONS

Arterial blood pressure
Heart rate
Cardiac output
Circulation time
Electrocardiography (ECG)
Phonocardiography

EXPERIMENT DURATION

35 min. daily for first week; then, 35 min. weekly for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

4 crew members
Ergometer
Cardiac output measurement equipment
Occlusive limb cuffs
Electrocardiograph
Phonocardiograph
Arterial pressure recorder
Cardiotachometer

SPECIAL REQUIREMENTS/REMARKS

Can be integrated with Experiment 1-21.

PERSONNEL REQUIRED

2 technicians

REFERENCES

S. P. Vinograd, Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-6

Effect of Blood Distribution on Arterial Pressure Control Systems

EXPERIMENT CATEGORY

Cardiovascular Function--Cardiovascular Deconditioning

OBJECTIVE AND SIGNIFICANCE

To determine the influence of prolonged weightlessness on the integrity of neutral reflex and humoral control mechanisms.

MEASUREMENTS AND OBSERVATIONS

Arterial blood pressure
Heart rate
Electrocardiography (ECG)
Urinary catecholamines
Blood catecholamines

EXPERIMENT DURATION

50 min. daily for first week; then, 50 min. weekly for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

4 crew members
Arterial pressure recorder
Cardiotachometer
Urine collection and storage equipment
Blood collection equipment
Biochemistry analysis equipment (catecholamines)
Electrocardiograph
Occlusive cuffs
Expiratory resistance device

SPECIAL REQUIREMENTS/REMARKS

Blood volume shifts can be achieved by Valsalva procedure, occlusive cuffs, and/or artificial gravity (short-radius centrifuge, LBNP). Techniques for catecholamine analysis unavailable at present.

PERSONNEL REQUIRED

1 physician and 1 technician

REFERENCES

S. P. Vinograd, Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-7

Alterations in Venous Compliance and Pressure Resulting from Absence of Hydrostatic Pressure

EXPERIMENT CATEGORY

Cardiovascular Function--Cardiovascular Deconditioning

OBJECTIVE AND SIGNIFICANCE

To determine if the reduced stress on the circulatory system, due to absence of hydrostatic pressure, results in alterations in venous compliance and/or venous pressure.

MEASUREMENTS AND OBSERVATIONS

Heart rate
Plethysmography (lower body limb)

EXPERIMENT DURATION

30 min. daily for first 10 days; then, 30 min. every 5 days for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 crew members
Cardiotachometer
Limb plethysmograph

SPECIAL REQUIREMENTS/REMARKS

Methods are equivocal. Additional R&D is required to increase confidence in them.

PERSONNEL REQUIRED

2 technicians

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D. C., 15 March 1965.
S. P. Vinograd, Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-8

Cardiac Dynamics

EXPERIMENT CATEGORY

Cardiovascular Function--Cardiovascular Deconditioning

OBJECTIVE AND SIGNIFICANCE

To determine if ballistocardiography can accurately measure cardiac dynamics and cardiac output in the weightless state.

MEASUREMENTS AND OBSERVATIONS

Phonocardiography
Ballistocardiography
Electrocardiography (ECG)
Cardiac output
Arterial blood pressure

EXPERIMENT DURATION

Assessment to be made during the times in which cardiac output for other experiments are determined; additional setup time per measurement is negligible.

SUBJECTS, MATERIALS, AND EQUIPMENT

3 crew members
Ballistocardiograph
Electrocardiograph
Cardiac output measurement equipment (various types)
Phonocardiograph
Arterial pressure recorder

SPECIAL REQUIREMENTS/REMARKS

Can be done in conjunction with other cardiovascular experiments which measure cardiac output.

PERSONNEL REQUIRED

2 technicians

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D. C., 15 March 1965.
S. P. Vinograd, Medical Aspects of an Orbiting Research Laboratory. Space Medicine Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-9

Intraocular Arterial Blood Pressure

EXPERIMENT CATEGORY

Cardiovascular Function--Extent of Cardiovascular Deconditioning during Weightlessness

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on intraocular systolic and diastolic blood pressure associated with possible loss in reactivity of the cardiovascular system. Adverse variations in intraocular blood pressure may threaten the limits of visual tolerance.

MEASUREMENTS AND OBSERVATIONS

Intraocular arterial systolic and diastolic blood pressure (measured by loss of retinal sensitivity)
Arterial blood pressure

EXPERIMENT DURATION

10 min., 4 times on first day; 10 min. daily on days 2, 4, 8, and 12; then, once weekly after 3, 6, and 12 weeks.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 crew members
Plethysmographic goggles
Vision test target
Arterial pressure recorder

SPECIAL REQUIREMENTS/REMARKS

Development of flight goggles with built-in pressure-recording system is required.

PERSONNEL REQUIRED

Subjects serve as their own observers

REFERENCES

S. P. Vinograd, Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-10

Use of a Lower-Body Negative Pressure Device to Prevent Cardiovascular Deconditioning

EXPERIMENT CATEGORY

Cardiovascular Function--Deconditioning Countermeasures

OBJECTIVE AND SIGNIFICANCE

To determine cardiovascular reponses to a lower-body negative pressure device in weightlessness and to evaluate the effectiveness of this device as a deconditioning countermeasure.

MEASUREMENTS AND OBSERVATIONS

Spirometry
Arterial blood pressure
Heart rate
Electrocardiography (ECG)
Electroencephalography (EEG)
Plethysmography (forearm)
Cardiac output

EXPERIMENT DURATION

30 min. for first 24 hours; then, 30 min. every 2 days for first 2 weeks; then, 30 min. weekly for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 crew members
Spirometer
Cardiotachometer
Electroencephalograph
Capacitance plethysmograph
Cardiac output measurement equipment
Electrocardiograph
Arterial pressure recorder

SPECIAL REQUIREMENTS/REMARKS

Design of lower body negative pressure device should be optimized. Additional evaluation of capacitance plethysmography is required.

PERSONNEL REQUIRED

1 physician and 1 technician

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D. C. 15 March 1965.
S. P. Vinograd, Medical Aspects of an Orbiting Research Laboratory. Space Medicine Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-11

Use of an On-Board Centrifuge to Prevent Cardiovascular Deconditioning

EXPERIMENT CATEGORY

Cardiovascular Function--Deconditioning Countermeasures

OBJECTIVE AND SIGNIFICANCE

To determine the effectiveness of the short-radius centrifuge as a conditioning device.

MEASUREMENTS AND OBSERVATIONS

Spirometry
Arterial blood pressure
Heart rate
Electrocardiography (ECG)
Cardiac output
Expiratory pO_2 and pCO_2
Plethysmography
Electroencephalography (EEG)
Body temperature

EXPERIMENT DURATION

20 min. daily for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

4 crew members
Spirometer
Arterial pressure recorder
Cardiotachometer
Electrocardiograph
Cardiac output measurement equipment
Expiratory gas analyzer
Capacitance plethysmograph
Cine camera
Temperature recorder
Electroencephalograph
Mass measurement device

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

1 physician and 1 technician

REFERENCES

Apollo Extension Systems Experiment List, NASA. Washington, D. C., 15 March 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-12

Use of Occlusive Cuffs to Prevent Cardiovascular Deconditioning

EXPERIMENT CATEGORY

Cardiovascular Function--Deconditioning Countermeasures

OBJECTIVE AND SIGNIFICANCE

To measure the cardiovascular response to occlusive cuffs during weightlessness and to evaluate their use as a deconditioning countermeasure.

MEASUREMENTS AND OBSERVATIONS

Spirometry
Arterial blood pressure
Heart rate
Electrocardiography (ECG)
Cardiac output
Expiratory pO_2 and pCO_2
Temperature
Plethysmography

EXPERIMENT DURATION

20 min. daily for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 crew members
Spirometer
Arterial pressure recorder
Cardiotachometer
Electrocardiograph
Cardiac output measurement equipment
Expiratory gas analyzer
Capacitance plethysmograph
Temperature recorder

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

1 physician and 1 technician

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D. C. 15 March 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-13

Sensitivity of the Carotid Sinus-Arterial Pressure Control Loop

EXPERIMENT CATEGORY

Cardiovascular Function--Sensitivity of Homeostatic Mechanisms

OBJECTIVE AND SIGNIFICANCE

To determine if the sensitivity of the carotid sinus control mechanism is significantly altered during weightlessness.

MEASUREMENTS AND OBSERVATIONS

Arterial blood pressure
Heart rate
Electrocardiography (ECG)
Cardiac output
Respiratory amplitude
Plethysmography (forearm)

EXPERIMENT DURATION

20 min. first day; then, 20 min. every 2 days for first 2 weeks; then 20 min. weekly for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 crew members
Arterial pressure recorder
Cardiotachometer
Electrocardiograph
Spirometer
Capacitance plethysmograph
Cardiac output measurement equipment
Carotid cuffs (individual)

SPECIAL REQUIREMENTS/REMARKS

Increase in transmural pressure in the carotid sinuses is obtained by subjecting neck to negative pressure with a molded plastic carotid cuff.

PERSONNEL REQUIRED

1 physician and 2 technicians

REFERENCES

S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-14

Peripheral Arteriolar Reactivity

EXPERIMENT CATEGORY

Cardiovascular Function--Sensitivity of Homeostatic Mechanisms

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on arteriolar tone. This is an assumed index of vascular reactivity and cardiovascular conditioning.

MEASUREMENTS AND OBSERVATIONS

Arterial blood pressure
Plethysmography
Venous and arterial filling time

EXPERIMENT DURATION

15 min. daily for 5 days; then, 15 min. at a 5- to 10-day intervals for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 or more crew members, as available
Capacitance plethysmograph
Arterial pressure recorder
Still camera (color and infrared sensitive film)
Limb pressure cuffs

SPECIAL REQUIREMENTS/REMARKS

Physician is desirable.

PERSONNEL REQUIRED

1 technician

REFERENCES

S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-15

Changes in Blood Volume and Distribution

EXPERIMENT CATEGORY

Cardiovascular Function--Blood Volume

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on fluid shifts among body compartments and the resulting influence on circulating blood volume.

MEASUREMENTS AND OBSERVATIONS

- Plasma volume
- Hematocrit
- Extracellular fluid volume
- Total body water
- Red blood cell mass
- Body mass
- Body volume
- Urinalysis

EXPERIMENT DURATION

1 hour daily for first 15 days; then, 1 hour weekly for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

- 3 crew members
- Clinical centrifuge
- Radioactive tracers
- Scintillation counter/scaler
- Biochemistry analysis equipment
- Mass measurement devices (large and small)
- Body volumeter
- Urine collection and storage equipment

SPECIAL REQUIREMENTS/REMARKS

Radioisotopic techniques are required for the measurement of plasma volume, red cell mass, extracellular fluid volume, and total body water. Physician is desirable for interpretation of results. Can be integrated with Experiments 1-33 and 1-45.

PERSONNEL REQUIRED

2 technicians

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D. C., 15 March 1965.
S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-16

Carotid Baroreceptor Electrical Activity in Primates

EXPERIMENT CATEGORY

Cardiovascular Function--Animal Research

OBJECTIVE AND SIGNIFICANCE

To determine the amount of afferent nervous discharge from the carotid baroreceptor during prolonged weightlessness.

MEASUREMENTS AND OBSERVATIONS

Arterial blood pressure
Electrocardiography (ECG)
Expiratory pO_2 and pCO_2
Temperature
Blood volume
Electrical activity from carotid sinus receptors
Hematocrit

EXPERIMENT DURATION

20-min. observations, 3 times weekly; thereafter, for indeterminate period.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 monkeys (rhesus or spider)
Arterial pressure recorder
Electrocardiograph
Temperature recorder
Oscilloscope and photographic recorder
Recording manometer
Radioactive tracers
Limb pressure cuffs
Scintillation counter/scaler
Expiratory gas analyzer
Cardiotachometer
Clinical centrifuge
Mass measurement device

SPECIAL REQUIREMENTS/REMARKS

Electrodes are implanted in animals prior to mission for measuring carotid sinus impulses.

PERSONNEL REQUIRED

2 technicians

REFERENCES

MDAC originated.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-17

Cardiac Output -- Direct Versus Indirect Methods

EXPERIMENT CATEGORY

Cardiovascular Function--Animal Research

OBJECTIVE AND SIGNIFICANCE

To evaluate the usefulness of indirect measurements for determining cardiac output as opposed to the direct Fick method.

MEASUREMENTS AND OBSERVATIONS

- Arterial blood pressure
- Right atrial pressure and pO_2
- Electrocardiography (ECG)
- Cardiac output by impedance, ballistocardiographic, and dye dilution methods
- Expiratory pO_2 and pCO_2
- Circulation time
- Temperature
- Body mass
- Spirometry
- Blood volume
- Hematocrit

EXPERIMENT DURATION

2 hours every 2 weeks for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

- 2 miniature swine
- Arterial pressure recorder
- Electrocardiograph
- Ballistocardiograph
- Temperature recorder
- Mass measurement devices (large and small)
- Expiratory gas analyzer
- Recording manometer
- Spirometer
- Cardiac output measurement device
- Cardiotachometer
- Clinical centrifuge
- Oscilloscope and recorder
- Spectrophotometer

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

2 technicians

REFERENCES

MDAC originated.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-18

Cardiovascular Response to Shock Therapy--Pharmacologically and Volumetrically Induced Vascular Collapse

EXPERIMENT CATEGORY

Cardiovascular Function--Animal Research

OBJECTIVE AND SIGNIFICANCE

To determine the response of the cardiovascular system to pharmacological and volumetric shock during prolonged weightlessness.

MEASUREMENTS AND OBSERVATIONS

- Arterial blood pressure
- Venous pressure
- Electrocardiography (ECG)
- Cardiac output (Fick)
- Expiratory pO_2 and pCO_2
- Circulation time
- Blood volume
- Hematocrit
- Body mass
- Esophageal pressure
- Venous pO_2 and pCO_2
- Right atrial pressure and pO_2
- Temperature
- Spirometry

EXPERIMENT DURATION

4 hours, to be scheduled as convenient.

SUBJECTS, MATERIALS, AND EQUIPMENT

- 2 dogs or miniature swine
- Arterial pressure recorder
- Electrocardiograph
- Temperature recorder
- Recording monometers
- Limb pressure cuffs
- Expiratory gas analyzer
- Mass measurement devices (large and small)
- Clinical centrifuge
- Cardiac output measurement device
- Cardiotachometer
- Spirometer
- Expiratory resistance device
- Oscilloscope and recorder
- Spectrophotometer

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

2 technicians

REFERENCES

MDAC originated.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-19

Pulmonary Mechanics

EXPERIMENT CATEGORY

Pulmonary Function--Ventilatory Mechanics

OBJECTIVE AND SIGNIFICANCE

To determine whether weightlessness produces shifts in lung volumes, changes in airway resistance, changes in respiratory muscle strength, or other alterations in pulmonary mechanics.

MEASUREMENTS AND OBSERVATIONS

Respiration rate
Total airway resistance (computed)
Maximum inspiratory and expiratory pressure
Spirometric volume and esophageal pressure (lung compliance)
Standard respiratory volumes
Maximum expiration flow rate
Esophageal pressure
Expired Air pO_2, pCO_2

EXPERIMENT DURATION

2 min. daily for first week; then, 2 min. weekly for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 crew members
Spirometer
Recording apparatus

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

1 technician

REFERENCES

S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-20

Respiration Control

EXPERIMENT CATEGORY

Pulmonary Function--Ventilatory Mechanics

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the respiration control associated with possible changes in respiratory gases, acid-base balance, and body reflexes.

MEASUREMENTS AND OBSERVATIONS

Respiration rate
Respiratory volumes
Expiratory pO_2 and pCO_2
Breath-holding time
Arterialized venous blood pH, bicarbonate, pO_2, and pCO_2
O_2-Hb saturation

EXPERIMENT DURATION

Spirometry 10 min. daily for mission duration; chemistries 60 min. weekly for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 crew members
Spirometer
Expiratory gas analyzer
pH meter
Specific ion electrodes
Blood gas analysis equipment
Oximeter
Timer

SPECIAL REQUIREMENTS/REMARKS

Available techniques need to be refined.

PERSONNEL REQUIRED

2 technicians

REFERENCES

S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-21

Blood and Ventilatory Gas Exchange

EXPERIMENT CATEGORY

Pulmonary Function--Pulmonary Efficiency

OBJECTIVE AND SIGNIFICANCE

To measure the changes in ventilatory gas exchange and in blood aeration caused by the possible adaptations to prolonged weightlessness.

MEASUREMENTS AND OBSERVATIONS

Expired air pO_2 and pCO_2
Arterialized venous blood pH, pO_2, pCO_2, and bicarbonate
Hemoglobin O_2 saturation
Respiratory rate and volume

EXPERIMENT DURATION

60 min. per determination twice weekly for both resting and exercising conditions for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 crew members
Expiratory gas analyzer
pH meter
Specific ion electrodes
Spirometer
Oximeter
Blood gas analysis equipment

SPECIAL REQUIREMENTS/REMARKS

Can be integrated with Experiment 1-21.

PERSONNEL REQUIRED

1 technician

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D. C., 15 March 1965.
S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-22

Lung Cleansing in Rats

EXPERIMENT CATEGORY

Pulmonary Function--Animal Research

OBJECTIVE AND SIGNIFICANCE

To determine the effectiveness of ciliary motion in removing small particles from the lung during prolonged weightlessness.

MEASUREMENTS AND OBSERVATIONS

Temperature
Tissue pathology (gross and microscopic)
White blood cell count

EXPERIMENT DURATION

60 min. daily for 15 days; then, 2 hours for termination and final sample preservation.

SUBJECTS, MATERIALS, AND EQUIPMENT

6 albino rats
Tissue fixatives
Nebulizer chamber
Temperature recorder
Aerosol particle analyzer
Dissecting microscope
Hemacytometer
Still camera (color film)

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

1 technician

REFERENCES

S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.
MDAC originated.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-23

Induced Pulmonary Infections in Mice

EXPERIMENT CATEGORY

Pulmonary Function--Animal Research

OBJECTIVE AND SIGNIFICANCE

To determine the resistance of mice to induced pulmonary infections during prolonged weightlessness.

MEASUREMENTS AND OBSERVATIONS

Temperature
Tissue pathology (gross and microscopic)
Hematocrit
White blood cell count

EXPERIMENT DURATION

10 min. readings daily for 2 weeks.

SUBJECTS, MATERIALS, AND EQUIPMENT

6 albino mice
Tissue fixatives
Nebulizer chamber
Bacteriology equipment
Still camera (color film)
Expiratory gas analyzer
Temperature recorder

SPECIAL REQUIREMENTS/REMARKS

Animal isolation facilities are required.

PERSONNEL REQUIRED

1 technician

REFERENCES

MDAC originated.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-24

Recovery Rate from Noninfectious Lung Trauma in Rats

EXPERIMENT CATEGORY

Pulmonary Function--Animal Research

OBJECTIVE AND SIGNIFICANCE

To determine the rate of lung-tissue healing after noninfectious trauma induced by exposure to an irritant gas.

MEASUREMENTS AND OBSERVATIONS

Temperature
Tissue pathology (gross and microscopic)
White blood cell count

EXPERIMENT DURATION

10 min. daily for 2 weeks; 30 min. sample preparation every third day.

SUBJECTS, MATERIALS, AND EQUIPMENT

6 albino rats
Tissue fixatives
Nebulizer chamber
Temperature recorder
Still camera (color film)

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

1 technician

REFERENCES

MDAC originated.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-25

Intestinal Absorption

EXPERIMENT CATEGORY

Gastrointestinal Function

OBJECTIVE AND SIGNIFICANCE

To determine the absorption rates of common foodstuffs during prolonged weightlessness.

MEASUREMENTS AND OBSERVATIONS

Absorption rates (radioisotopically labelled foods)
Body and specimen masses

EXPERIMENT DURATION

60 min. weekly for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 crew members
Radioactive tracers
Scintillation counter/scaler
Mass measurement devices (large and small)
Urine and feces storage unit

SPECIAL REQUIREMENTS/REMARKS

Waste management equipment with sampling capability is required.

PERSONNEL REQUIRED

1 technician

REFERENCES

Integrated Medical Behavioral Laboratory Measurement System. NASA RFP 10-1243, December 1966.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-26

Gastrointestinal Motility and pH

EXPERIMENT CATEGORY

Gastrointestinal Function--Function and Motility

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on gastric secretion and gastrointestinal motility. Available data indicate that prolonged stress could result in increased acid secretion with peptic ulceration.

MEASUREMENTS AND OBSERVATIONS

Motility (pressure waves)
Stomach volume
Stomach contraction rate and force
Gastric pH
Hunger pain (subjective opinion)

EXPERIMENT DURATION

25 min. twice a day, every 7 days for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 crew members
Imbibed transmitter (endoradiosonde)
Rubber balloon
Stomach tube (Rehfuss)
Pressure transducers and recorder or oscilloscope
pH meter

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

2 technicians

REFERENCES

Apollo Extension Systems Experiments. NASA, Washington, D. C., 15 March 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-27

Indices of Renal Function

EXPERIMENT CATEGORY

Renal Function

OBJECTIVE AND SIGNIFICANCE

To determine the influence of prolonged weightlessness on kidney function and possible urinary calculus formation. Changes in body position on Earth are known to alter renal function, but long-term effects associated with spaceflight are unknown.

MEASUREMENTS AND OBSERVATIONS

Blood urea nitrogen
Serum electrolytes
Serum creatinine
Urinalysis
Urine creatinine
Urine osmolality
Urine volume
Body and specimen mass

EXPERIMENT DURATION

2 hours weekly for mission duration (independent of number of subjects).

SUBJECTS, MATERIALS, AND EQUIPMENT

All crew members
Spectrophotometer
Specific ion electrodes
Osmometer
Mass measurement devices (large and small)
pH meter

SPECIAL REQUIREMENTS/REMARKS

Waste management system with sampling and measurement capability is required.

PERSONNEL REQUIRED

1 technician

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D. C., 15 March 1965.
S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-28

Renal Calculus Formation in Rats

EXPERIMENT CATEGORY

Renal Function--Animal Research

OBJECTIVE AND SIGNIFICANCE

To determine whether prolonged weightlessness affects the rate of renal and bladder calculus formation.

MEASUREMENTS AND OBSERVATIONS

Histology (kidney and bladder)
Serum electrolytes
Urinalysis
Urine calcium and phosphorus
Urine osmolality
Urine volume

EXPERIMENT DURATION

10 min. daily for 4 weeks. (1 hour for sample preparation at experiment conclusion.)

SUBJECTS, MATERIALS, AND EQUIPMENT

6 albino rats
Tissue fixatives
Spectrophotometer
Specific ion electrodes
Osmometer
Urine collection equipment
pH meter

SPECIAL REQUIREMENTS/REMARKS

Ground-based research required to establish techniques for enhancement of calculus formation. Provision for urine collection is required.

PERSONNEL REQUIRED

1 technician

REFERENCES

MDAC originated.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-29

Renal Infection in Rats

EXPERIMENT CATEGORY

Renal Function--Animal Research

OBJECTIVE AND SIGNIFICANCE

To determine whether induced ascending renal infection is more rapidly progressive in weightlessness.

MEASUREMENTS AND OBSERVATIONS

Histology
Urinalysis
Urine culture
White blood cell count
Cultures of renal tissue

EXPERIMENT DURATION

30 min. daily for 2 weeks. (2 hours for sample preparation at experimental conclusion.)

SUBJECTS, MATERIALS, AND EQUIPMENT

4 albino rats with partial ureteral ligation
Tissue fixatives
Osmometer
Bacteriology equipment

SPECIAL REQUIREMENTS/REMARKS

Provision for urine collection is required.

PERSONNEL REQUIRED

1 technician

REFERENCES

MDAC originated.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-30

Energy Metabolism

EXPERIMENT CATEGORY

Nutrition, Metabolism--General Metabolism

OBJECTIVE AND SIGNIFICANCE

To determine the effect of prolonged weightlessness on metabolic rates and patterns.

MEASUREMENTS AND OBSERVATIONS

Body mass
Body volume
Expiratory pO_2 and pCO_2
Inspiratory pO_2 and pCO_2
Body temperature

EXPERIMENT DURATION

15 min. daily for first week; then, 15 min. weekly for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 crew members
Body volumeter
Expiratory gas analyzer
Temperature recorder
Ergometer
Mass measurement devices

SPECIAL REQUIREMENTS/REMARKS

24-hour representative total energy metabolism can be made from selected short-duration measurements of typical activities determined by time-and-motion studies. Can be integrated with Experiment 1-31.

PERSONNEL REQUIRED

1 technician

REFERENCES

S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-31

Carbohydrate and Fat Metabolism

EXPERIMENT CATEGORY

Nutrition, Metabolism--General Metabolism

OBJECTIVE AND SIGNIFICANCE

To determine to what extent prolonged weightlessness alters carbohydrate and fat metabolism.

MEASUREMENTS AND OBSERVATIONS

Body mass
Expiratory pO_2 and pCO_2
Blood glucose
Urine glucose
Blood-free fatty acids
Serum phosphorus

EXPERIMENT DURATION

1 hour per chemical measurement (independent of number of subjects) weekly for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 crew members
Mass measurement devices (large and small)
Specific ion electrodes
Expiratory gas analyzer
Biochemistry analysis equipment

SPECIAL REQUIREMENTS/REMARKS

Can be integrated with Experiment 1-30 for respiratory quotient determination and with Experiment 1-33. Additional development is required for blood fatty-acid determination technique.

PERSONNEL REQUIRED

1 technician

REFERENCES

S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE

TEXT REF. NO. 1-32

Protein Metabolism

EXPERIMENT CATEGORY

Nutrition, Metabolism--General Metabolism

OBJECTIVE AND SIGNIFICANCE

To determine whether weightlessness affects nitrogen turnover rates to the extent that the disturbed metabolic function becomes incompatible with effective performance.

MEASUREMENTS AND OBSERVATIONS

Recorded nitrogen intake
Body Mass
Body volume
Urine nitrogen
Fecal nitrogen
Blood urea nitrogen

EXPERIMENT DURATION

60 min. per sample (after 24-hour collection periods) every other day for first 2 weeks; then, weekly for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 crew members
Mass measurement devices (large and small)
Body volumeter
Urine and feces collection equipment for 24-hr samples
Nitrogen analyzer
Urine and feces storage units

SPECIAL REQUIREMENTS/REMARKS

Waste management system is designed for aliquot samplings of 24-hour collections. Automated nitrogen analyzer requires development. Can be integrated with Experiment 1-33.

PERSONNEL REQUIRED

1 technician

REFERENCES

S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-33

Fluid and Electrolyte Balance

EXPERIMENT CATEGORY

Nutrition, Metabolism--Body Fluids

OBJECTIVE AND SIGNIFICANCE

To determine the effect of prolonged spaceflight on water balance and electrolyte metabolism. Studies on Earth indicate that changes in fluid balance accompany changes in body position.

MEASUREMENTS AND OBSERVATIONS

- Body mass and volume
- Total body water
- Blood volume
- Plasma volume
- Red blood cell mass
- Extracellular fluid volume
- Serum proteins
- Serum electrolytes
- Serum (blood) pH
- Blood glucose
- Urine titratable acidity
- Urine osmolality
- Urine glucose
- Urine nitrogen
- Urine creatine and creatinine

EXPERIMENT DURATION

1 hour weekly for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

- 2 crew members
- Body volumeter
- Radioactive tracer materials
- Scintillation counter/scaler
- Spectrophotometer
- Electrophoresis apparatus
- Expiratory gas analyzer
- Mass measurement devices
- Biochemistry analysis equipment
- Specific ion electrodes
- pH meter
- Osmometer
- Refrigeration unit
- Ergometer
- Nitrogen analyzer

SPECIAL REQUIREMENTS/REMARKS

Diet must be controlled. Can be integrated with Experiments 1-15, 1-31, and 1-32. Additional research and development is required for chemistry techniques.

PERSONNEL REQUIRED

2 technicians

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D. C., 15 March 1965.
S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-34

Mineral Metabolism

EXPERIMENT CATEGORY

Nutrition, Metabolism--General Metabolism

OBJECTIVE AND SIGNIFICANCE

To determine the effect of prolonged weightlessness and physical inactivity on mineral metabolism. Data will be used to develop corrective measures necessary for maintaining normal mineral balance.

MEASUREMENTS AND OBSERVATIONS

Serum, urinary, and stool calcium and phosphorus
Serum alkaline phosphatase
Fecal mass

EXPERIMENT DURATION

4 hours per measurement weekly (independent of number of subjects) for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 crew members
Spectrophotometer
Ergometer
Biochemistry analysis equipment
Urine and feces collection and storage equipment

SPECIAL REQUIREMENTS/REMARKS

Can be integrated with Experiments 2-31, 2-32, and 2-33. Additional research is required to develop on board techniques for chemical analyses.

PERSONNEL REQUIRED

1 technician

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D. C., 15 March 1965.
S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-35

Bone Density

EXPERIMENT CATEGORY

Musculoskeletal Function -- Skeletal Decalcification

OBJECTIVE AND SIGNIFICANCE

To determine whether prolonged weightlessness will result in significant skeletal decalcification. Limited results during brief orbital flights indicate that such changes are probable, but the ultimate extent and pattern of bone decalcification is unknown.

MEASUREMENTS AND OBSERVATIONS

Bone density
Blood, urine, and stool calcium and phosphorus
Serum alkaline phosphotase

EXPERIMENT DURATION

30 min. weekly for mission duration. (Preflight control measurements of bone density; post-flight measurements for 3 days.)

SUBJECTS, MATERIALS, AND EQUIPMENT

All crew members
Bone densitometer
Urine and feces collection and storage
Biochemistry analysis equipment

SPECIAL REQUIREMENTS/REMARKS

R&D is required for lightweight densitometry equipment. Investigation of isotope radiation source and ultrasound technique is under development. Chemical determinations done in Experiments 2-31, 2-32, 2-33, and 2-34.

PERSONNEL REQUIRED

1 technician

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D. C., 15 March 1965.

S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-36

Muscle Mass and Strength

EXPERIMENT CATEGORY

Musculoskeletal Function -- Work Capacity, Exercise, and Deconditioning

OBJECTIVE AND SIGNIFICANCE

To determine the effect of prolonged weightlessness on work capacity and muscle strength and to determine the effectiveness of exercise as a means of preventing deconditioning.

MEASUREMENTS AND OBSERVATIONS

Muscle size
Urine creatinine
Urine creatine
Blood lactic acid
Blood creatinine
Muscle strength

EXPERIMENT DURATION

40-min. twice weekly for first 4 weeks; then, 40 min. weekly for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

3 crew members
Ergometer
Muscle dynamometer
Biochemistry analysis equipment
Urine collection equipment

SPECIAL REQUIREMENTS/REMARKS

Basic research required to correlate muscle size with work capacity. Chemical determinations done in Experiments 2-27 and 2-34.

PERSONNEL REQUIRED

1 technician

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D. C., 15 March 1965.

S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study. NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-37

Electromyography as an Index of Deconditioning

EXPERIMENT CATEGORY

Musculoskeletal Function -- Deconditioning Indices

OBJECTIVE AND SIGNIFICANCE

To develop and apply the techniques of electromyography for determining the extent of deconditioning occurring during prolonged spaceflight.

MEASUREMENTS AND OBSERVATIONS

Serum calcuium, phosphorus, and alkaline phosphotase
Bone density
Muscle size
Urine creatinine
Urine creatine
Electromyography
Blood lactic acid
Blood creatinine
Muscle strength

EXPERIMENT DURATION

20-min. twice weekly for first 4 weeks; then, 20 min. weekly for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

3 crew members
Ergometer
Electromyograph and recorder
Muscle dynamometer
Biochemistry analysis equipment
Bone densitometer

SPECIAL REQUIREMENTS/REMARKS

Chemical determinations done in Experiments 2-27 and 2-34.

PERSONNEL REQUIRED

1 technician

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D.C., 15 March 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-38

Fracture Healing in Animals

EXPERIMENT CATEGORY

Musculoskeletal Function -- Animal Research

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the rate of fracture healing.

MEASUREMENTS AND OBSERVATIONS

Calcium turnover rate
Bone formation rate
Serum calcium, phosphorus, and alkaline phosphotase
Bone density
Histology

EXPERIMENT DURATION

10 min. daily and 1 hour weekly for 6 weeks. (2 hours for sample preparation at experiment conclusion.)

SUBJECTS, MATERIALS, AND EQUIPMENT

6 guinea pigs
Radioactive tracers
Radioactivity counter/scaler
Bone densitometer
Tissue fixatives
Biochemistry analysis equipment

SPECIAL REQUIREMENTS/REMARKS

Tests should be conducted early in the mission before appreciable deconditioning has occurred so that there can be a comparison with results obtained during end of mission.

PERSONNEL REQUIRED

2 technicians

REFERENCES

MDAC originated.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-39

Induction of Pressure Atrophy

EXPERIMENT CATEGORY

Musculoskeletal Function -- Animal Research

OBJECTIVE AND SIGNIFICANCE

To determine the rate of pressure-induced bone atrophy during weightlessness.

MEASUREMENTS AND OBSERVATIONS

Calcium turnover rate
Bone formation rate
Serum calcium, phosphorus, and alkaline phosphotase
Bone density
Histology

EXPERIMENT DURATION

2 hours weekly for 6 weeks.

SUBJECTS, MATERIALS, AND EQUIPMENT

3 guinea pigs
Radioactive tracers
Bone densitometer
Radioactivity counter/scaler
Biochemistry analysis equipment
Tissue fixatives

SPECIAL REQUIREMENTS/REMARKS

Best technique for determining turnover rates must be determined. This experiment will use analytic equipment of other biochemistry experiments.

PERSONNEL REQUIRED

1 technician

REFERENCES

MDAC originated.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-40

Endocrine Function and Stress Physiology

EXPERIMENT CATEGORY

Endocrine Function -- Stress

OBJECTIVE AND SIGNIFICANCE

To determine and quantitate the effect of prolonged spaceflight on pituitary, thyroid, adrenal, gonadal, and neurohumoral functions.

MEASUREMENTS AND OBSERVATIONS

Expiratory pO_2 and pCO_2
Urinary 17-hydroxy steroids
Urinary aldosterone
Urinary 17 ketosteroids
Urinary catecholamines
Urinary serotonin
Blood PBI, and ACTH
Sperm count and motility (pre- and post-flight)
Histological evaluation
Urine volume and osmolality
Fluid electrolytes

EXPERIMENT DURATION

1-hour sample collection and preparation twice weekly for first 4 weeks; then, 1 hour weekly for missile duration. (Time for on-board analysis undetermined.)

SUBJECTS, MATERIALS, AND EQUIPMENT

2 or 3 crew members
Ergometer
Temperature recorder
Osmometer
Urine storage
Refrigeration unit
Specific ion electrodes
Frozen storage unit
Spectrophotometer
Biochemistry analysis equipment
Tissue fixatives
Expiratory gas analyzer
Specific hormone assay equipment

SPECIAL REQUIREMENTS/REMARKS

R&D is required for on-board hormone analysis. Ground determinations may be required.

PERSONNEL REQUIRED

1 technician

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D.C., 15 March 1965.

S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-41

Temperature Regulation Mechanisms

EXPERIMENT CATEGORY

Endocrine Function -- Thermoregulation

OBJECTIVE AND SIGNIFICANCE

To determine the effect of various stresses of prolonged spaceflight on physiological mechanisms of temperature regulation.

MEASUREMENTS AND OBSERVATIONS

Blood PBI
Temperature (ambient)
Skin and core temperature
Humidity
Blood flow
Blood TSH
Airflow volume
Fluid electrolytes
Expiratory pO_2 and pCO_2

EXPERIMENT DURATION

30 min. daily for first week; then, 30 min. weekly for mission duration. (Time undetermined for on-board analysis of samples, but estimated at 6 hours.)

SUBJECTS, MATERIALS, AND EQUIPMENT

2 crew members
Constantan-silver thermocouple
Specific hormone assay equipment
Temperature recorder
Specific ion electrodes
Expiratory gas analyzer
Spectrophotometer
Ergometer
Humidity recorder
Gas flowmeter

SPECIAL REQUIREMENTS/REMARKS

Methods for separating evaporative from nonevaporative heat losses are required. Methods for specific analyses have not yet been developed.

PERSONNEL REQUIRED

1 technician

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D.C., 15 March 1965.

S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-42

Adrenal and Parathyroid Function in Rats

EXPERIMENT CATEGORY

Endocrine Function (Stress) -- Animal Research

OBJECTIVE AND SIGNIFICANCE

To observe both histological and biochemical parameters of adrenal and parathyroid activity in animals during weightlessness and extra imposed stresses.

MEASUREMENTS AND OBSERVATIONS

Urinary 17-hydroxy steroids
Urinary aldosterone
Urinary 17 ketosteroids
Urinary catecholamines
Histological evaluation
Urine volume and osmolality
Fluid electrolytes

EXPERIMENT DURATION

60-min. sample collection and preparation weekly; 4-hour on-board sample analysis weekly.

SUBJECTS, MATERIALS, AND EQUIPMENT

6 albino rats
Specific hormone assay equipment
Tissue fixatives
Urine storage
Refrigeration unit
Frozen storage unit

SPECIAL REQUIREMENTS/REMARKS

Development is required for specific hormone assays.

PERSONNEL REQUIRED

1 technician

REFERENCES

MDAC originated.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-43

Gonad Histopathology

EXPERIMENT CATEGORY

Endocrine Function (Stress) -- Animal Research

OBJECTIVE AND SIGNIFICANCE

To determine the effect of prolonged weightlessness and radiation flux on gonadal histopathology and function.

MEASUREMENTS AND OBSERVATIONS

Sperm count and motility
Histology

EXPERIMENT DURATION

30-min. sample preparation weekly. (Total number of samples to be determined by mission duration.)

SUBJECTS, MATERIALS, AND EQUIPMENT

2 to 6 albino rats (actual number to be determined)
Tissue fixatives
Radiation dosimeter
Microscope
Hemocytometer

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

1 technician

REFERENCES

MDAC originated.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-44

Leukocyte Replication

EXPERIMENT CATEGORY

Hematologic Function -- Blood Cytogenetics

OBJECTIVE AND SIGNIFICANCE

To determine the effect of prolonged spaceflight on chromosomal activity of hemic cells during replication and division.

MEASUREMENTS AND OBSERVATIONS

White blood cell count (total and differential)
Cell morphology
Cytogenetic examination

EXPERIMENT DURATION

40 min. daily for first 2 days; then, every 10 days for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

All crew members
Cytology stains
Photomicrographic apparatus (color film)

SPECIAL REQUIREMENTS/REMARKS

Techniques for cytogenetic studies during spaceflight need to be developed.

PERSONNEL REQUIRED

1 technician

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D. C., 15 March 1965.

S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-45

Erythrocyte Dynamics

EXPERIMENT CATEGORY

Hematologic Function -- Blood Cell Dynamics

OBJECTIVE AND SIGNIFICANCE

To determine the effect of the various combinations of spaceflight environment on the proliferation, distribution, and destruction of human erythrocytes.

MEASUREMENTS AND OBSERVATIONS

Hematocrit
Red blood cell mass, count, fragility, and survival time
Plasma volume
Reticulocyte count
Hemoglobin
Cell morphology

EXPERIMENT DURATION

1 hour every 4 days for first 4 weeks; then, 1 hour every 10 days for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 crew members
Radioactive tracers
Scintillation counter/scaler
Cytology stains
Hemoglobinometer

SPECIAL REQUIREMENTS/REMARKS

Can be integrated with Experiment 1-15 for blood volume and red blood cell mass measurements.

PERSONNEL REQUIRED

1 technician

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washintgon, D. C., 15 March 1965.

S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-46

Leukocyte Dynamics

EXPERIMENT CATEGORY

Hematologic Function -- Blood Cell Dynamics

OBJECTIVE AND SIGNIFICANCE

To determine the effect of space environment on leukocyte proliferation, distribution, and destruction. Phagocytic action of leukocytes may be impaired in weightlessness.

MEASUREMENTS AND OBSERVATIONS

White blood cell count (total and differential)
White blood cell motility and phagocytosis
Cell morphology

EXPERIMENT DURATION

30 min. every 4 days for first month; then, 30 min. every 10 days for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 to 3 crew members
Incubator (37°C)
Microscope
Hemocytometer
Cytology stains
Photomicrographic apparatus (color film)

SPECIAL REQUIREMENTS/REMARKS

Standardized technique for phagocytic index must be determined.

PERSONNEL REQUIRED

1 technician

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D.C., 15 March 1965.

S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-47

Platelet Dynamics

EXPERIMENT CATEGORY

Hematologic Function -- Blood Cell Dynamics

OBJECTIVE AND SIGNIFICANCE

To measure the effect of prolonged weightlessness on platelet dynamics

MEASUREMENTS AND OBSERVATIONS

Cell morphology
Platelet count
Blood clotting time and clot retraction

EXPERIMENT DURATION

30 min. every 4 days for first 4 weeks; then, 30 min. every 10 days for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 or 3 crew members
Cytology stains
Photomicrographic apparatus (color film)
Incubator (37°C)

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

1 technician

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D.C., 15 March 1965.

S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-48

Blood Coagulation and Hemostatic Function

EXPERIMENT CATEGORY

Hematologic Function -- Coagulation System Integrity

OBJECTIVE AND SIGNIFICANCE

To determine if prolonged spaceflight changes blood coagulation and hemostatis. Possible pooling of blood may cause thrombosis. This experiment makes it possible for the first time to observe spontaneous blood clotting under conditions where the blood has no contact with external surfaces.

MEASUREMENTS AND OBSERVATIONS

Bleeding time
Platelet count
Blood clotting time
Clot retraction

EXPERIMENT DURATION

30 min. every 4 days for first 4 weeks; then, 30 min. every 10 days for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 or 3 crew members
Cytology stains
Incubator (37°C)
Photomicrographic apparatus (color film)

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

1 technician

REFERENCES

S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-49

Leukocyte Mobilization in Mice after Chemical Challenge

EXPERIMENT CATEGORY

Hematologic Function -- Animal Research

OBJECTIVE AND SIGNIFICANCE

To determine whether weightlessness affects leukocyte mobilization after challenge with a pharmacologically active agent (endotoxin).

MEASUREMENTS AND OBSERVATIONS

White blood cell count (total and differential)
White blood cell motility and phagocytic index
Cell morphology

EXPERIMENT DURATION

30 min. every hour for total of 12 hours.

SUBJECTS, MATERIALS, AND EQUIPMENT

4 albino mice
Cytology stains
Photomicrographic apparatus

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

1 technician

REFERENCES

MDAC originated.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-50

Maximum Rate of Erythrocyte Production in Rats

EXPERIMENT CATEGORY

Hematologic Function -- Animal Research

OBJECTIVE AND SIGNIFICANCE

To determine the influence of weightlessness on the rate of erythrocyte production in animals after maximum stimulation by blood loss.

MEASUREMENTS AND OBSERVATIONS

Hematocrit
Red blood cell mass, count, and survival time
Reticulocyte count
Cell morphology

EXPERIMENT DURATION

1 hour every 3 days for 2 weeks.

SUBJECTS, MATERIALS, AND EQUIPMENT

4 albino rats or mice
Cytology stains
Photomicrographic apparatus (color film)
Clinical centrifuge
Radioactive tracers
Radioactivity counter/scaler
Hemoglobinometer

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

1 technician

REFERENCES

MDAC originated.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-51

Wound Healing

EXPERIMENT CATEGORY

Hematologic Function -- Animal Research

OBJECTIVE AND SIGNIFICANCE

To determine the influence of weightlessness on the healing rates for lacerations, thermal burns, contusions, and abrasions.

MEASUREMENTS AND OBSERVATIONS

White blood cell count (total and differential)

EXPERIMENT DURATION

10 min. daily and 1-hour photography every third day for 2 to 6 weeks.

SUBJECTS, MATERIALS, AND EQUIPMENT

6 miniature swine
Still camera (color film)
Microscope
Hemacytometer

SPECIAL REQUIREMENTS/REMARKS

Experiments should include a variation in g level, if possible.

PERSONNEL REQUIRED

1 technician

REFERENCES

Medical Requirements in Support of Long Duration Manned Space Flight. Bellcomm, Inc., Report No. TR-67-710-1, 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-52

Microbial Evaluation of Surfaces

EXPERIMENT CATEGORY

Microbiology/Immunology -- Ecology

OBJECTIVE AND SIGNIFICANCE

To survey microbial profiles of equipment surfaces and to follow changes during mission progress.

MEASUREMENTS AND OBSERVATIONS

Bacterial and fungal enumerations and gross identification.

EXPERIMENT DURATION

1 hour twice weekly.

SUBJECTS, MATERIALS, AND EQUIPMENT

All crew members
Incubator (37°C)
Microbial culture media and equipment
Colony counter
Lyophilization apparatus
Refrigerated storage
Autoclave
Photomicrography equipment
Frozen storage unit

SPECIAL REQUIREMENTS/REMARKS

Design of equipment for null-gravity manipulations is required. Additional R&D on rapid identification methods is warranted.

PERSONNEL REQUIRED

1 technician

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D.C., 15 March 1965.

Integrated Medical Behavioral Laboratory Measurement System. NASA RFP 10-1243, 1966.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-53

Microbial Profiles of Crew Members

EXPERIMENT CATEGORY

Microbiology/Immunology -- Ecology

OBJECTIVE AND SIGNIFICANCE

To determine microbial profiles of crew members in a closed ecosystem under conditions of prolonged stress and weightlessness.

MEASUREMENTS AND OBSERVATIONS

Bacterial (aerobic and anaerobic) enumeration and identification
Sample collection

EXPERIMENT DURATION

10-min. sample collection and 6-hour evaluation and preservation of samples. (To be done weekly for mission duration or as required by clinical status of crew members.)

SUBJECTS, MATERIALS, AND EQUIPMENT

All crew members
Bacteriological culture media and equipment
Incubator (37°C)
Refrigerated storage
Frozen storage
Lyophilization apparatus
Photomicrographic equipment
Autoclave
Colony counter

SPECIAL REQUIREMENTS/REMARKS

Development of techniques applicable to zero-g environment and for rapid identification of bacteria is warranted.

PERSONNEL REQUIRED

1 technician

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D. C., 15 March 1965.

Integrated Medical Behavioral Laboratory Measurement System. NASA RFP 10-1243, 1966.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-54

Air Sampling for Microorganisms

EXPERIMENT CATEGORY

Microbiology/Immunology -- Ecology

OBJECTIVE AND SIGNIFICANCE

To determine possible alterations in airborne microbial contaminant loads caused by prolonged spaceflight.

MEASUREMENTS AND OBSERVATIONS

Bacterial and fungal enumeration and gross identification
Storage of representative microflora

EXPERIMENT DURATION

30 min. daily for first 2 weeks; then, 30 min. every other day for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

Anderson and Reyniers air samplers
Incubator (37°C)
Refrigerated storage
Lyophilization apparatus
Colony counter
Bacterial culture media and equipment
Frozen storage unit
Autoclave
Photomicrography equipment

SPECIAL REQUIREMENTS/REMARKS

Development of techniques to facilitate determinative bacteriology in zero-g environment is desirable.

PERSONNEL REQUIRED

1 technician

REFERENCES

MDAC originated.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 1-55

Immunological Survey of Crew Members

EXPERIMENT CATEGORY

Microbiology/Immunology -- Ecology

OBJECTIVE AND SIGNIFICANCE

To assess changes which may occur in the amount and type of serum immune components in subjects exposed to prolonged spaceflight.

MEASUREMENTS AND OBSERVATIONS

Sample collection and preparation of serum immune components

EXPERIMENT DURATION

15 min. every 1 to 2 weeks for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

All crew members
Frozen storage unit

SPECIAL REQUIREMENTS/REMARKS

Analyses to be done after mission completion.

PERSONNEL REQUIRED

1 technician

REFERENCES

Apollo Extension Systems Experiment List. NASA, Washington, D. C., 15 March 1965.

S. P. Vinograd. Medical Aspects of an Orbiting Research Laboratory. Space Medical Advisory Group Study, NASA Report No. SP-86, 1964.

BEHAVIORAL RESEARCH EXPERIMENT LIST

2-1 Accessibility
2-2 Restraint and Fine-Force Generation
2-3 Restraint and Gross-Force Generation
2-4 Personnel Translation
2-5 Mass Translation
2-6 Orientation, Stability, and Restraint
2-7 Communication and Recording
2-8 Monitoring and Observation
2-9 Higher Mental Function
2-10 Visual Function
2-11 Auditory Function
2-12 Somesthetic Function
2-13 Orientation Senses
2-14 Chemical Sense Function
2-15 Psychomotor Functions
2-16 Food Management
2-17 Water Management
2-18 Waste Management
2-19 Hygiene System
2-20 Volume and Layout
2-21 Clothing
2-22 Interior Design
2-23 Recreation
2-24 Intrapersonal Factors
2-25 Interpersonal Factors
2-26 Work/Rest/Sleep Cycles

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-1

Accessibility

EXPERIMENT CATEGORY

Mission Activities

OBJECTIVE AND SIGNIFICANCE

To evaluate task performance involving various whole-body and body-extremity accesses; to establish performance level and access envelop characteristics; to evaluate related techniques, equipment, and metabolic costs.

MEASUREMENTS AND OBSERVATIONS

Locomotion
Dexterity
Voice record
Event record
Time
Energy expenditure

EXPERIMENT DURATION

30 min. (repeated 3 to 5 times at 30-day intervals).

SUBJECT, MATERIALS, AND EQUIPMENT

1 crew member
Audio recorder
Timer
Metabolic monitor
Log book
Cameras (cine, still, and/or TV) and lights
Tape measure
Locomotion aids
Restraints

SPECIAL REQUIREMENTS/REMARKS

High-contrast grid pattern on two or more background surfaces is required for relatively accurate measurement and calibration of anthropometric data of body movements using photographic equipment. Relates to Experiments 2-4, 2-5, and 2-20.

PERSONNEL REQUIRED

1 observer

REFERENCES

Mission and Experiment Program Requirements for a One-Year Space Station. George C. Marshall Space Flight Center, February 1967.

Manned Space Flight Experiment Summary. George C. Marshall Space Flight Center, February 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-2

Restraint and Fine-Force Generation

EXPERIMENT CATEGORY

Mission Activities

OBJECTIVE AND SIGNIFICANCE

To assess the crew's manipulative dexterity in performing simulated mission tasks, and to evaluate related restraint techniques and metabolic costs. Results will be used in validating procedures, equipment, techniques, and training requirements.

MEASUREMENTS AND OBSERVATIONS

Manipulation
Force production
Time
Energy expenditure
Voice record
Event record
Subjective opinion

EXPERIMENT DURATION

20 min. (repeated 3 to 5 times, at 30-day intervals).

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
Timer
Metabolic monitor
Torque-force apparatus
Audio recorder
Cameras (cine, still, and/or TV) and lights
Log book
Tools
Restraints
Questionnaires
Ergometer

SPECIAL REQUIREMENTS/REMARKS

May be integrated with command-control and display instrumentation. Standardized questionnaires must be developed.

PERSONNEL REQUIRED

1 observer

REFERENCES

Mission and Experiment Program Requirements for a One-Year Space Station. George C. Marshall Space Flight Center, February 1967.

NASA Experiment Descriptions for Extended Apollo Earth-Orbit Flights. NASA Headquarters, Washington, D. C., March 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-3

Restraint and Gross-Force Generation

EXPERIMENT CATEGORY

Mission Activities

OBJECTIVE AND SIGNIFICANCE

To assess the crew's gross motor behavior and ability to apply large forces, and to evaluate mission-task performance and related restraints and techniques. Results will be used in validating procedures, techniques, equipment training requirements, and metabolic costs.

MEASUREMENTS AND OBSERVATIONS

Locomotion
Dexterity
Force production
Time
Energy expenditure
Voice record
Event record
Subjective opinion

EXPERIMENT DURATION

30 min., (repeated 3 to 5 times at 30-day intervals).

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
Timer
Metabolic monitor
Torque-force apparatus
Audio recorder
Cameras (cine, still, and/or TV) and lights
Log book
Tools
Restraints
Questionnaires
Ergometer

SPECIAL REQUIREMENTS/REMARKS

Standardized questionnaires must be developed.

PERSONNEL REQUIRED

1 observer

REFERENCES

Mission and Experiment Program Requirements for a One-Year Space Station. George C. Marshall Space Flight Center, February 1967.

NASA Experiment Descriptions for Extended Apollo Earth-Orbit Flights. NASA Headquarters, Washington, D. C., March 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-4

Personnel Translation

EXPERIMENT CATEGORY

Mission Activities

OBJECTIVE AND SIGNIFICANCE

To assess the crew's ability to translate by using various manual techniques; to validate procedures, equipment, techniques, and related matabolic costs; and to identify unusual training requirements.

MEASUREMENTS AND OBSERVATIONS

Dexterity
Locomotion
Time
Energy expenditure
Event record
Voice record
Subjective opinion

EXPERIMENT DURATION

25 min. (repeat 3 to 5 times--same subject with each device--at 30-day intervals).

SUBJECTS, MATERIALS AND EQUIPMENT

1 crew member
Timer
Metabolic monitor
Log book
Questionnaires
Audio recorder
Cameras (cine, still, and/or TV) and lights
Restraints
Locomotion aids

SPECIAL REQUIREMENTS/REMARKS

Standardized questionnaires must be developed. Grid pattern against at least one background surface is desirable. Randomized utilization of devices is required. Relates to Experiment 2-21.

PERSONNEL REQUIRED

1 observer

REFERENCES

Mission and Experiment Program Requirements for a One-Year Space Station. George C. Marshall Space Flight Center, February 1967.

EVEA Program Requirements Study, Final Report. North American Rockwell Report No. SD-68-304-7, 1968.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-5

Mass Translation

EXPERIMENT CATEGORY

Mission Activities

OBJECTIVE AND SIGNIFICANCE

To establish the limits of the crew's ability to move various mass configurations by using various restraint, tether, and maneuvering techniques and to validate procedures, training requirements, and metabolic costs.

MEASUREMENTS AND OBSERVATIONS

Locomotion
Mass motion and acceleration
Energy expenditure
Voice record
Event record
Time
Dexterity
Subjective opinion

EXPERIMENT DURATION

50 min. (repeated 3 to 5 times at 30-day intervals).

SUBJECTS, MATERIALS, AND EQUIPMENT

2 crew members
Accelerometers and recorders
Metabolic monitor
Audio recorder
Cameras (cine, still, and/or TV) and lights
Log book
Timer
Questionnaires
Restraints
Locomotion aids

SPECIAL REQUIREMENTS/REMARKS

Standardized questionnaires must be developed. Preferably performed in large-volume compartment. Acceleration profiles of masses must be obtainable without interference with mass motion. Background grid pattern is desirable. Relates to Experiments 2-1 and 2-21.

PERSONNEL REQUIRED

1 observer

REFERENCES

EVEA Program Requirements Study, Final Report. North American Rockwell Report No. SD-68-304-7, 1968.

Manned Space Flight Experiment Summary. George C. Marshall Space Flight Center, February 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-6

Orientation, Stability, and Restraint

EXPERIMENT CATEGORY

Mission Activities

OBJECTIVE AND SIGNIFICANCE

To evaluate the crew's integrated performance efficiency in maneuvering and orienting the body in relation to task location and to evaluate man/equipment combinations, related techniques, and metabolic costs.

MEASUREMENTS AND OBSERVATIONS

Body acceleration
Body position
Voice record
Energy expenditure
Event record
Time

EXPERIMENT DURATION

15 min. (repeat 3 to 5 times at 30-day intervals).

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
Accelerometers and recorder
Metabolic monitor
Audio recorder
Cameras (cine, still, and/or TV) and lights
Log book
Timer
Locomotion aids
Restraints

SPECIAL REQUIREMENTS/REMARKS

Man's acceleration profile must be obtainable without interference with body motion. High-contrast grid pattern on background surfaces is desirable. (Measurements of linear and angular thresholds are included in biomedicine and human research experiments.)

PERSONNEL REQUIRED

1 observer

REFERENCES

Mission and Experiment Program Requirements for a One-Year Space Station. George C. Marshall Space Flight Center, February 1967.

EVEA Program Requirements Study, Final Report. North American Rockwell Report No. SD-68-304-7, 1968.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-7

Communications and Recording

EXPERIMENT CATEGORY

Mission Activities

OBJECTIVE AND SIGNIFICANCE

To evalute the crew's ability to communicate information and record data as a function of exposure to orbital stressors.

MEASUREMENTS AND OBSERVATIONS

Dexterity
Manipulation
Event record
Voice record
Control/display dynamics
Time
Subjective opinion

EXPERIMENT DURATION

15 min. at 21-day intervals

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
Paper and pen tests
Audio recorder
CRT and other information displays
Information display associated controls
Cameras (cine, still, and/or TV) and lights
Timer
Log book
Questionnaires

SPECIAL REQUIREMENTS/REMARKS

Standardized questionnaires must be developed. May be integrated with spacecraft control-display instrumentation. Major proportion of data may be automatically recorded.

PERSONNEL REQUIRED

1 observer for event recording

REFERENCES

NASA Experiment Descriptions for Extended Apollo Earth-Orbit Flights. NASA Headquarters, Washington, D. C., March 1965.

Manned Space Flight Experiment Summary. George C. Marshall Space Flight Center, February 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-8

Monitoring and Observation

EXPERIMENT CATEGORY

Mission Activities

OBJECTIVE AND SIGNIFICANCE

To assess the crew's ability to perform integrated operational tasks involving sensing, identification, and interpretation functions for an extended time in orbit and to establish performance levels and training requirements.

MEASUREMENTS AND OBSERVATIONS

Event record
Voice record
Time
Reaction time
Subjective opinion

EXPERIMENT DURATION

30 min. (dependent upon overriding mission tasks being performed) at 30-day intervals.

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
Audio recorder
Cameras (cine, still, and/or TV) and lights
Log book
Timer
CRT and other information displays
Information display controls
Questionnaires

SPECIAL REQUIREMENTS/REMARKS

May be accomplished as an integrated measurement during docking or other mission segments requiring sensory orientation and/or sensory discrimination and other perceptual and psychomotor functions. Major proportion of data may be automatically recorded through integration with spacecraft controls and displays. Standardized questionnaires must be developed.

PERSONNEL REQUIRED

1 observer

REFERENCES

Manned Space Flight Experiment Summary. George C. Marshall Space Flight Center, February 1967.

Report on the Development of the Manned Orbital Research Laboratory (MORL) System Utilization Potential, Task Area 1, Analysis of Space-Related Objectives, Book 2. Douglas Report No. SM-48808, September 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-9

Higher Mental Function

EXPERIMENT CATEGORY

Mission Activities

OBJECTIVE AND SIGNIFICANCE

To assess the crew's operational efficiency through the measurement of readily observable behavior, such as the performance of command and control tasks or other tasks involving higher level functions. Results will be used to validate crew composition and training requirements, procedures, techniques, and related equipment.

MEASUREMENTS AND OBSERVATIONS

Vigilance
Attention
Problem solving
Memory
Judgment
Event record
Voice record
Time
Subjective opinion

EXPERIMENT DURATION

20 min. at 30-day intervals. (Parameters may vary from session to session.)

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
CRT displays and controls
Information displays and associated controls
Analog recorder
Audio recorder
Paper and pen tests
Questionnaires
Log book

SPECIAL REQUIREMENTS/REMARKS

May be integrated with spacecraft control-display instrumentation. Standardized questionnaires must be developed.

PERSONNEL REQUIRED

1 observer

REFERENCES

NASA Experiment Descriptions for Extended Apollo Earth-Orbit Flights. NASA Headquarters, Washington, D. C., March 1965.

Medical Aspects of an Orbiting Research Laboratory. NASA Space Medicine Advisory Group. NASA Report No. SP-86, 1966.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-10

Visual Function

EXPERIMENT CATEGORY

Basic Behavioral Integrity

OBJECTIVE AND SIGNIFICANCE

To evaluate the integrity of the crew's visual processes as a function of time in orbit and to identify changes in discrete visual parameters which could degrade operational efficiency.

MEASUREMENTS AND OBSERVATIONS

- Visual acuity
- Depth perception (static and dynamic)
- Light and dark adaptation
- Eye movement
- Form discrimination
- Veridicality (perception of the vertical)
- Critical flicker fusion
- Color detection/discrimination
- Brightness detection/discrimination
- Voice record
- Event record
- Subjective opinion

EXPERIMENT DURATION

10 min. at 21-day intervals (alternate parameters measured.)

SUBJECTS, MATERIALS, AND EQUIPMENT

- 1 crew member
- Orthorater
- Light source (static and dynamic-dual)
- CFF source
- Veridicality tester
- Cameras (cine, still, and/or TV) and lights
- Timer
- Color plates
- Audio recorder
- Log book
- Questionnaires
- Electro-oculograph and recorder

SPECIAL REQUIREMENTS/REMARKS

Standardized questionnaires must be developed. Light source and veridicality tests may require design and development lead time. Many measurements can be combined through use of flexible testing device such as McDonnel Douglas Visual/Auditory Test or Integrated Medical or Behavioral Laboratory Measurement System. Most measurements require ability to extinguish cabin and/or background illumination.

PERSONNEL REQUIRED

1 observer

REFERENCES

NASA Experiment Descriptions for Extended Apollo Earth-Orbit Flights. NASA Headquarters, Washington, D. C., March 1965.

Report on the Optimization of the Manned Orbital Research Laboratory (MORL) System Concept, Phase IIa, Vols, XXII and XXIII, Experiment Program. Douglas Report Nos. SM-46083 and SM-46084, September 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-11

Auditory Function

EXPERIMENT CATEGORY

Basic Behavioral Integrity

OBJECTIVE AND SIGNIFICANCE

To evaluate the integrity of the crew's auditory processes as a function of time in orbit. Results will be used to identify changes in discrete visual parameters which could degrade operational efficiency.

MEASUREMENTS AND OBSERVATIONS

Auditory detection/discrimination
Event record
Noise sensitivity
Voice record
Time

EXPERIMENT DURATION

10 min. at 21-day intervals

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
Pure tone source
Timer
Audio recorder
Noise and vibration source
Log book

SPECIAL REQUIREMENTS/REMARKS

Pure tone source may require design development for flight qualification.

PERSONNEL REQUIRED

Subject only

REFERENCES

Mission and Experiment Program Requirements for a One-Year Space Station. George C. Marshall Space Flight Center, February 1967.

NASA Experiment Descriptions for Extended Apollo Earth-Orbit Flights. NASA Headquarters, Washington, D. C., March 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-12

Somesthetic Function

EXPERIMENT CATEGORY

Basic Behavioral Integrity

OBJECTIVE AND SIGNIFICANCE

To evaluate the integrity of the crew's somesthetic function for extended time in orbit and to identify changes in discrete sensory processes which could degrade operational efficiency and/or indicate an undesirable physiological condition.

MEASUREMENTS AND OBSERVATIONS

Skin sensitivity
Event record
Voice record

EXPERIMENT DURATION

30 min. at 21-day intervals.

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
Cotton tufts
Needles
Tuning fork
Audio recorder
Log book

SPECIAL REQUIREMENTS/REMARKS

Method of controlled heating and cooling of needles may be required. Special training of test conductor in the method of stimulus introduction is required.

PERSONNEL REQUIRED

1 observer

REFERENCES

Symposium on Psychophysiological Aspects of Space Flight. B. Flaherty, editor. Columbia University Press, New York, 1961.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-13

Orientation Senses

EXPERIMENT CATEGORY

Basic Behavioral Integrity

OBJECTIVE AND SIGNIFICANCE

To assess the functional integrity of nonvisually augmented body-position sense in relation to time in orbit and to evaluate the crew's ability to maintain cognizance of body and extremity position in relation to the spacecraft.

MEASUREMENTS AND OBSERVATIONS

Time
Body position
Event record
Voice record
Subjective opinion

EXPERIMENT DURATION

30 min. at 30-day intervals.

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
Questionnaires
Cameras (cine, still, and/or TV) and lights
Log book
Audio recorder
Timer

SPECIAL REQUIREMENTS/REMARKS

Standardized questionnaires must be developed. Assessment of spatial orientation may require high-contrast grid backgrounds within large volumetric enclosure. Related to Experiment 1-2.

PERSONNEL REQUIRED

1 observer

REFERENCES

NASA Experiment Descriptions for Extended Apollo Earth-Orbit Flights. NASA Headquarters, Washington, D. C., March 1965.

Experiment Selection and Definition for S-IVB applications. Douglas Report No. SM-60569, December 1966.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-14

Chemical Sense Function

EXPERIMENT CATEGORY

Basic Behavioral Integrity

OBJECTIVE AND SIGNIFICANCE

To assess the functional integrity of the crew's sense of taste and smell as a function of exposure to prolonged space travel and to identify discrete changes in chemical sense parameters which could indicate physiological degradation.

MEASUREMENTS AND OBSERVATIONS

Taste thresholds and anomalies (sour, salty, bitter, and sweet)
Olfactory thresholds and anomalies (fragrant, acid, burnt, and caprylic)
Event record
Voice record
Time

EXPERIMENT DURATION

1.5 hours at 30-day intervals (with alternating sessions for taste and olfactory measurements).

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
Standard olfactory aerosols
Standard gustatory solutions
Microsyringes
Dionized sterile water
Log book
Audio recorder
Timer

SPECIAL REQUIREMENTS/REMARKS

Accurate thermal control of all equipment is mandatory. Control of aerosols and solutions may present development problems. Special training in introducing stimulus is required.

PERSONNEL REQUIRED

1 observer

REFERENCES

MDAC originated.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-15

Psychomotor Functions

EXPERIMENT CATEGORY

Basic Behavioral Integrity

OBJECTIVE AND SIGNIFICANCE

To assess the functional integrity of selected psychomotor functions for intended time periods in orbit. Results will be used to provide monitoring requirements for future systems, and predictive information regarding changes in behavior and physiology.

MEASUREMENTS AND OBSERVATIONS

Reaction time
Complex sequence
Manipulation
Tracking
Time
Event record
Voice record
Energy expenditure
Subjective opinion

EXPERIMENT DURATION

30 min. at 21-day intervals. (Parameters to be varied from session to session.)

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
Standard dexterity apparatus
Metabolic monitor
CRT and other displays
Display associated controls
Cameras (cine, still, and/or TV) and lights
Restraints
Timer
Log book
Audio recorder
Questionnaires

SPECIAL REQUIREMENTS/REMARKS

Experiment should utilize an integrated performance measurement apparatus, such as the Integrated Medical or Behavioral Laboratory Measurement System. Standardized questionnaires must be developed.

PERSONNEL REQUIRED

Subject only, if automatic recording available

REFERENCES

NASA Experiment Descriptions for Extended Apollo Earth-Orbit Flights. NASA Headquarters, Washington, D. C., March 1965.

Report on the Development of the Manned Orbital Research Laboratory (MORL) System Utilization Potential, Task Area 1, Analysis of Space-Related Objectives, Book 2. Douglas Report No. SM-48808, September 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-16

Food Management

EXPERIMENT CATEGORY

Habitability

OBJECTIVE AND SIGNIFICANCE

To evaluate various food types and packaging and handling techniques for long-duration missions; to provide design information and to validate techniques, procedures, and equipment.

MEASUREMENTS AND OBSERVATIONS

Manipulation
Dexterity
Subjective opinion
Event record
Food consumption
Time
Voice record

EXPERIMENT DURATION

10 min. at 30-day intervals

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
Log book
Questionnaires
Audio recorder
Cameras (cine, still, and/or TV) and lights
Timer

SPECIAL REQUIREMENTS/REMARKS

Standardized questionnaires must be developed. Will interface with Experiments 1-30 through 1-34, and 2-14.

PERSONNEL REQUIRED

1 observer

REFERENCES

Mission and Experiment Program Requirements for a One-Year Space Station. George C. Marshall Space Flight Center, February 1967.

National Multipurpose Space Station. NASA Manned Spacecraft Center, December 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-17

Water Management

EXPERIMENT CATEGORY

Habitability

OBJECTIVE AND SIGNIFICANCE

To evaluate water potability and handling techniques for long-duration missions; to provide design information; and to validate techniques, procedures, and equipment.

MEASUREMENTS AND OBSERVATIONS

Subjective opinion
Water consumption
Time
Voice record
Event record
Manipulation
Dexterity

EXPERIMENT DURATION

10 min. at 30-day intervals.

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
Log book
Questionnaires
Audio recorder
Cameras (cine, still, and/or TV) and lights
Timer

SPECIAL REQUIREMENTS/REMARKS

Standardized questionnaires must be developed. May interface with Experiment 2-14.

PERSONNEL REQUIRED

1 observer

REFERENCES

Mission and Experiment Program Requirements for a One-Year Space Station. George C. Marshall Space Flight Center, February 1967.

Manned Space Flight Experiment Summary. George C. Marshall Space Flight Center, February 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-18

Waste Management

EXPERIMENT CATEGORY

Habitability

OBJECTIVE AND SIGNIFICANCE

To evaluate efficiency and acceptability of waste management system for long-duration missions and to validate techniques, procedures, and equipment.

MEASUREMENTS AND OBSERVATIONS

Subjective opinion
Event record
Time
Dexterity
Locomotion

EXPERIMENT DURATION

5 to 10 min. at 30-day intervals.

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
Cameras (cine, still, and/or TV) and lights
Audio recorder
Timer
Log book
Questionnaires

SPECIAL REQUIREMENTS/REMARKS

Standardized questionnaires must be developed. High-contrast background grid patterns may be required for body motion measurement.

PERSONNEL REQUIRED

1 observer for event recording

REFERENCES

Mission and Experiment Program Requirements for a One-Year Space Station. George C. Marshall Space Flight Center, February 1967.

Manned Space Flight Experiment Summary. George C. Marshall Space Flight Center, February 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-19

Hygiene System

EXPERIMENT CATEGORY

Habitability

OBJECTIVE AND SIGNIFICANCE

To evaluate efficiency and acceptability of hygiene system for long-duration missions and to validate techniques, procedures, equipment, and metabolic costs.

MEASUREMENTS AND OBSERVATIONS

Energy expenditure
Subjective opinion
Event record
Time
Voice record
Manipulation
Dexterity

EXPERIMENT DURATION

10 min. at 30-day intervals.

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
Cameras (cine, still, and/or TV) and lights
Audio recorder
Timer
Log book
Questionnaires
Metabolic monitor

SPECIAL REQUIREMENTS/REMARKS

Standardized questionnaires must be developed.

PERSONNEL REQUIRED

1 observer for event recording

REFERENCES

Mission and Experiment Program Requirements for a One-Year Space Station. George C. Marshall Space Flight Center, February 1967.

NASA Experiment Descriptions for Extended Apollo Earth-Orbit Flights. NASA Headquarters, Washington, D. C., March 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-20

Volume and Layout

EXPERIMENT CATEGORY

Habitability

OBJECTIVE AND SIGNIFICANCE

To evaluate efficiency and acceptability of volumes and layouts associated with spacecraft compartments and areas designed for long-duration missions and to validate design criteria and operational procedures and techniques.

MEASUREMENTS AND OBSERVATIONS

Subjective opinion
Event record
Locomotion
Dexterity
Time
Voice record
Area/compartment utilization frequency

EXPERIMENT DURATION

10 min. at 30-day intervals.

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
Cameras (cine, still, and/or TV) and lights
Audio recorder
Timer
Log book
Questionnaires

SPECIAL REQUIREMENTS/REMARKS

Standardized questionnaires and recreational facilities requirements must be developed. Movable partitions for investigation of volumetric provisions will be required. Relates to Experiments 2-1 and 2-21.

PERSONNEL REQUIRED

1 observer for event recording

REFERENCES

Mission and Experiment Program Requirements for a One-Year Space Station. George C. Marshall Space Flight Center, February 1967.

Medical Aspects of an Orbiting Research Laboratory. NASA Space Medicine Advisory Group. NASA Report No. SP-86, 1966.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-21

Clothing

EXPERIMENT CATEGORY

Habitability

OBJECTIVE AND SIGNIFICANCE

To evaluate efficiency and acceptability of constant-wear and protective clothing designed for long-duration missions and to provide design information.

MEASUREMENTS AND OBSERVATIONS

Subjective opinion
Event record
Body position
Energy expenditure
Voice record
Time
Dexterity
Locomotion

EXPERIMENT DURATION

15 min. at 30-day intervals.

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
Cameras (cine, still, and/or TV) and lights
Audio recorder
Timer
Log book
Questionnaires
Metabolic monitor

SPECIAL REQUIREMENTS/REMARKS

Standardized questionnaires must be developed. Metabolic monitoring not necessary for all clothing configurations. All differential pressures to be encountered with EVA clothing must be evaluated. No proposed experiment considers clothing acceptability as a dependent variable.

PERSONNEL REQUIRED

1 observer for event recording

REFERENCES

Mission and Experiment Program Requirements for a One-Year Space Station. George C. Marshall Space Flight Center, February 1967.

National Multipurpose Space Station. NASA Manned Spacecraft Center, December 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-22

Interior Design

EXPERIMENT CATEGORY

Habitability

OBJECTIVE AND SIGNIFICANCE

To evaluate interior design of spacecraft for long-duration missions, including reactions to lighting, color, and general atmosphere; to validate design requirements; and to improve operational efficiency through maintenance of high levels of morale and motivation.

MEASUREMENTS AND OBSERVATIONS

Subjective opinion
Mood assessment
Voice record
Event record

EXPERIMENT DURATION

10 min. at 30-day intervals.

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
Questionnaires
Audio recorder
Log book
Paper and pen tests

SPECIAL REQUIREMENTS/REMARKS

Standardized questionnaires must be developed. Relates to Experiments 2-21 and 2-20.

PERSONNEL REQUIRED

Subject only

REFERENCES

Mission and Experiment Program Requirements for a One-Year Space Station. George C. Marshall Space Flight Center, February 1967.

Manned Space Flight Experiment Summary. George C. Marshall Space Flight Center, February 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-23

Recreation

EXPERIMENT CATEGORY

Habitability

OBJECTIVE AND SIGNIFICANCE

To evaluate recreation provisions for long-duration missions; to validate design and provisioning requirements; and to improve operational efficiency of crew through maintenance of high levels of morale and motivation.

MEASUREMENTS AND OBSERVATIONS

Subjective opinion
Area/compartment utilization frequency
Event record
Voice record
Time

EXPERIMENT DURATION

10 min. at 30-day intervals.

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
Cameras (cine, still, and/or TV) and lights
Log book
Questionnaires
Timer
Audio recorder

SPECIAL REQUIREMENTS/REMARKS

Standardized questionnaires must be developed.

PERSONNEL REQUIRED

1 observer

REFERENCES

MDAC originated.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-24

Intrapersonal Factors

EXPERIMENT CATEGORY

Habitability

OBJECTIVE AND SIGNIFICANCE

To assess the emotional stability of individual crew members as a function of time in orbit. Results will be used to improve psychological adjustment and crew selection criteria.

MEASUREMENTS AND OBSERVATIONS

Emotional assessment
GSR
Electroencephalography (EEG)
Subjective opinion
Voice record
Event record

EXPERIMENT DURATION

15 min. at 30-day intervals.

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
Paper and pen tests
Galvanic skin response and EEG sensors and recorders
Audio recorder
Questionnaires
Log book

SPECIAL REQUIREMENTS/REMARKS

Standardized questionnaires must be developed. Reliable, long-term Earth-based measures must be available for baseline comparison. It may be desirable to assess these parameters utilizing active spacecraft/ground communications links.

PERSONNEL REQUIRED

1 ground observer

REFERENCES

National Multipurpose Space Station. NASA Manned Spacecraft Center, December 1964.

Medical Aspects of an Orbiting Research Laboratory. NASA Space Medicine Advisory Group. NASA Report No. SP-86, 1966.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-25

Interpersonal Factors

EXPERIMENT CATEGORY

Habitability

OBJECTIVE AND SIGNIFICANCE

To evaluate internal group processes as a function of time in orbit. Results will be used to improve psychological adjustment and crew selection criteria.

MEASUREMENTS AND OBSERVATIONS

Event record
Voice record
Subjective opinion
Emotional assessment

EXPERIMENT DURATION

15 min. at 30-day intervals.

SUBJECTS, MATERIALS, AND EQUIPMENT

1 crew member
Paper and pen tests
Audio recorder
Log book
Questionnaires

SPECIAL REQUIREMENTS/REMARKS

Reliable long-term Earth-based measures of group processes must be available for baseline comparison. It may be desirable to assess these parameters utilizing active spacecraft/ground communications link. Standardized questionnaires must be developed.

PERSONNEL REQUIRED

1 ground observer

REFERENCES

Mission and Experiment Program Requirements for a One-Year Space Station. George C. Marshall Space Flight Center, February 1967.

Medical Aspects of an Orbiting Research Laboratory. NASA Space Medicine Advisory Group. NASA Report No. SP-86, 1966.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 2-26

Work/Rest/Sleep Cycles

EXPERIMENT CATEGORY

Habitability

OBJECTIVE AND SIGNIFICANCE

To evaluate various work/rest/sleep cycles for long-duration missions and to verify crew requirements.

MEASUREMENTS AND OBSERVATIONS

*Temperature
*Urinary excretion of steroids
*Heart rate
*Blood pressure
*Electroencephalography (EEG)
Judgment
Dexterity
Manipulation
Attention
Memory
Vigilance
Tracking
Reaction time
Problem solving
Subjective opinion
Critical flicker fusion
Event record
Time
Voice record

EXPERIMENT DURATION

30 min. at 30-day intervals.

SUBJECTS, MATERIALS, AND EQUIPMENT

All crew members
Audio recorder
Timer
Log book
Metabolic monitor
Questionnaires
Ergometer
EEG sensors and recorder

SPECIAL REQUIREMENTS/REMARKS

*Should be combined with appropriate biomedical experiments. Standardized questionnaires must be developed.

PERSONNEL REQUIRED

1 observer

REFERENCES

Medical Aspects of an Orbiting Research Laboratory. NASA Space Medicine Advisory Group. NASA Report No. SP-86, 1966.

BIOSCIENCE RESEARCH EXPERIMENT LIST

3-1 Primate Behavior
3-2 Mouse Growth and Behavior
3-3 Teleost Behavior
3-4 Predator-Prey Behavioral Patterns in Daphnia
3-5 Cockroach Feeding, Walking, and Mating Behavior
3-6 Drosophila Behavior
3-7 Ant Behavior
3-8 Dinoflagellate Behavior
3-9 Primate Biorhythms
3-10 Mouse Biorhythms
3-11 Cockroach Biorhythms
3-12 Drosophila Pupal Eclosion
3-13 Capsicum-Seedling and Mature-Plant Biorhythms
3-14 Avena Biorhythms
3-15 Genetic Background of Morphologic Adaptation in the Flounder
3-16 Drosophila Genetics
3-17 Amoeba Genetics
3-18 E. coli Genetics
3-19 E. coli Lysogenic (T4) Genetics
3-20 Neurospora Genetics
3-21 Teleost Geosensitivity
3-22 Drosophila Geosensitivity
3-23 Capsicum Tropisms
3-24 Root and Shoot Tropisms
3-25 Human Cells Geosensitivity
3-26 Primate Hemodynamics
3-27 Primate Metabolism
3-28 Mouse Metabolism
3-29 Daphnia Metabolism
3-30 Drosophila Metabolism
3-31 Crown Gall Metabolism
3-32 Avena Metabolism
3-33 Dinoflagellate Metabolism
3-34 Neurospora Metabolism
3-35 Frog Egg Morphogenesis
3-36 Fish Morphogenesis
3-37 Daphnia Morphogenesis
3-38 Flatworm Morphogenesis
3-39 Drosophila Morphogenesis
3-40 Crown Gall Morphogenesis
3-41 Avena Morphogenesis
3-42 Amaranthus Morphogenesis
3-43 Amoeba Morphogenesis
3-44 Bromeliad Morphogenesis

3-45 Crown Gall Parasitism
3-46 Spontaneous and Induced Mouse Leukemia
3-47 Amoeba Parasitism
3-48 Human Cell Reproduction
3-49 Primate Radiation
3-50 Flatworm Regeneration

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-1

Primate Behavior

EXPERIMENT CATEGORY

Mammalian Behavior

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the behavior of a confined, near-human mammal, including vestibular influences on sustained performances, cued establishment of an artificial horizon, and physiological correlates.

MEASUREMENTS AND OBSERVATIONS

Heart rate and Electrocardiography (ECG)
Electroencephalography (EEG)
Electromyography (EMG)
Blood pressures (arterial and venous)
Galvanic skin response (GSR)
Brain and core temperature
Intracranial pressure
Respiration rate
Fecal analysis
Body Water/Extracellular Fluid
Body mass
Nitrogen balance
Bone X-ray density
Gross body activities
Orientation
Ergometric performance
Metabolic rate
Urinalysis (Na, Cl, Ca)
Body temperature
Food (and Water) Intake/Waste Output
Blood pH
Blood flow rate
Mineral balance

DESIRED MISSION DURATION

60 to 120 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 chimpanzees (1 restrained)
Geodesic modules
Cine camera
Animal restraints
Exerciser/ergometer
*Electroencephalograph
*Electro oculograph
*Electromyograph
*Electrocardiograph
Freezer
Bone densitometer
Mass measurement device (macro)
UV/visible spectro photometer
Polarographic sensors
Recorder (potentiometric)
Organism centrifuge (large)
Radiation shielding

SPECIAL REQUIREMENTS/REMARKS

Can be integrated with Experiment 3-9.
*Part of geodesic modules.

PERSONNEL REQUIRED

2 technicians

REFERENCES

W. R. Adey and J. P. Meehan. Physiology of Chimpanzees in Orbit. UCLA-USC Joint Experiment on Chimpanzees in Prolonged Orbit, February 1968.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-2

Mouse Growth and Behavior

EXPERIMENT CATEGORY

Mammalian Behavior

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the behavior of a small mammal; and to determine the changes in the growth and behavior of mice bred and raised in weightlessness.

MEASUREMENTS AND OBSERVATIONS

Orientation
Growth and development
Gross body activities
Reproductive behavior
Ergometric/behavioral performance

DESIRED MISSION DURATION

1 year.

SUBJECTS, MATERIALS, AND EQUIPMENT

4 mice (initially), then 16 mice at end of 1 year of in-orbit breeding
Cameras (TV, cine, and still)
Exerciser/ergometer
Necropsy kit
Organism centrifuge (small)
Freezer
Reproduction module

SPECIAL REQUIREMENTS/REMARKS

Mice are to be recovered. Experiment is completely self-contained. Laboratory test model has been constructed. The animal module has a central nesting area and a peripheral feeding area.

PERSONNEL REQUIRED

1 technician

REFERENCES

J. P. Meehan, Orbiting Experiment for Study of Extended Weightlessness, Vol. VI: Long Term Adaptation to a Weightless Environment. Northrop Systems Laboratories (NAS1-6971), December 1967.

J. P. Meehan and J. P. Henry. Space Life Sciences, Vol. I, 1965, Pages 97-112.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-3

Teleost Behavior

EXPERIMENT CATEGORY

Vertebrate Behavior

OBJECTIVE AND SIGNIFICANCE

To study the adaptive behavior of small aquatic vertebrates in weightlessness. Increase, loss, or reversal of aggressive behavior during weightlessness would be of considerable interest from the standpoint of survival.

MEASUREMENTS AND OBSERVATIONS

Dorsal light reflex tropism
Behavioral performance

DESIRED MISSION DURATION

30 to 60 days.

SUBJECTS, MATERIALS

Guppies and/or certain species of fighting fish
Cameras (TV, cine, and still)
Aquarium
Dissecting kit

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Annual Progress Report. Bioscience Research during Manned Earth-Orbiting Missions, Part Two. 24 October 1966.

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-4

Predator-Prey Behavioral Patterns in Daphnia

EXPERIMENT CATEGORY

Invertebrate Behavior

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the daphnia's predator-prey pattern toward the hydra polyp. With given density of predators and prey, the ability of the predator to recognize, locate, capture, and ingest prey will be determined, as well as the ability of the prey to avoid predation. Reproductive activity of predator and prey will be monitored also.

MEASUREMENTS AND OBSERVATIONS

Orientation
Gross body activities
Growth and development
Reproductive behavior
Behavioral performance

DESIRED MISSION DURATION

30 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Freshwater flea (daphnia pulex)
Freshwater polp (hydra species)
Daphnia containers
Cameras (TV, cine, and still)
Dissecting kit
Compound microscope set
Stereo-dissecting microscope

SPECIAL REQUIREMENTS/REMARKS

Since hydra specimens would be involved in the daphnia behavior experiment, it would be valuable to study some of the unique features of hydra concomitantly. Chlamydomonas algae will be the food source for the daphnia.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Annual Progress Report. Bioscience Research during Manned Earth-Orbiting Missions, Part Two. 24 October 1966.

R. P. Casey and A. L. Burnett. The Effect of Weightlessness upon Frequency of Cell Division and differentiation. Biological Experiments in Space. North American Aviation, Inc., 1963.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-5

Cockroach Feeding, Walking, and Mating Behavior

EXPERIMENT CATEGORY

Invertebrate Behavior

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the feeding, walking, and mating behavior of an invertebrate animal of insect order.

MEASUREMENTS AND OBSERVATIONS

Behavioral performance
Orientation
Gross body activities
Reproductive behavior

DESIRED MISSION DURATION

30 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Cockroaches (blattidae species), male and female
Cameras (TV, cine, and still)
Insect chambers
Dissecting kit

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Annual Progress Report. Bioscience Research during Manned Earth-Orbiting Missions, Part Two. 24 October 1966.

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-6

Drosophila Behavior

EXPERIMENT CATEGORY

Invertebrate behavior

OBJECTIVE AND SIGNIFICANCE

To determine the effect on weightlessness on the behavior of an invertebrate animal of the insect group. The drosophila has been used extensively for genetic analyses; hence, some insight into the genetic aspects of behavior may be obtained.

MEASUREMENTS AND OBSERVATIONS

Gross body activities
Orientation
Ergometric/behavioral performance
Reproductive behavior

DESIRED MISSION DURATION

3 to 14 days (longer for multiple-generation behavior).

SUBJECTS, MATERIALS, AND EQUIPMENT

Drosophila melanogaster (all life cycle stages), male and female
Drosophila facility with incubator
Dissecting microscope
Micromanipulators
Cameras (TV, color cine, and still)
Dissecting kit

SPECIAL REQUIREMENTS/REMARKS

Individuals born in space and completing life cycles in space should be observed. Several generations of drosophila should be studied for behavioral effects in orbit. Predator-prey behavior (quail as predator) may be studied.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-7

Ant Behavior

EXPERIMENT CATEGORY

Invertebrate Behavior

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the behavior of a colonial form of invertebrate animal of the insect group. Both group and individual relationships, including social hierarchy, should be studied. The absence of terrestrial cues or the presence of nonstereotyped postures in space may be of significance.

MEASUREMENTS AND OBSERVATIONS

Group and individual behavior
Orientation
Gross body activities
Reproductive behavior

DESIRED MISSION DURATION

30 to 60 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Ants (colonial form), male and female
Dissecting microscope (binocular)
Ant growth chambers
Micromanipulators
Cameras (TV, cine, and still)

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-8

Dinoflagellate Behavior

EXPERIMENT CATEGORY

Invertebrate Behavior

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the behavior of a unicellular invertebrate with certain rhythmic periodicities.

MEASUREMENTS AND OBSERVATIONS

Luminescence (timing of periodicities)
Cell division
Biological rhythms
Cytology
Orientation

DESIRED MISSION DURATION

90 to 120 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Gonyaulax polyedora (dinoflagellate species)
Portozoan growth chambers
Compound microscope set
UV/visual spectrophotometer
Recorder (potentiometric)
Timer
Cameras (TV, cine, and still)

SPECIAL REQUIREMENTS/REMARKS

Rhythms in luminescence, photosynthesis, and cell division can be entrained by alterations in light-dark cycles, by light qualtiy, and by temperature.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report, Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-9

Primate Biorhythms

EXPERIMENT CATEGORY

Vertebrate Biorhythms

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the biorhythms of a near-human mammal.

MEASUREMENTS AND OBSERVATIONS

Persistence of terrestrial diurnal cycles
Spontaneous development of new rhythms
Evaluation of self-selected and imposed environmental rhythms
Corneal capillary "sludging"
Test performance
Gross body activities

DESIRED MISSION DURATION

60 to 120 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 chimpanzees (1 restrained)
Camera (cine)
Mass measurement device (macro)
Exerciser/ergometer
Geodesic housing chambers with waste management systems
Stereo-binocular microscope
Freezer
Restraint
Bone densitometer
Dissecting kit

SPECIAL REQUIREMENTS/REMARKS

Corneal capillary microcirculation should be observed for diurnal "sludging". Periodic maneuvers, noises, and vibrations should be avoided. Can be integrated with Experiment 3-1. Housing should include lights with sequential tracking switches.

PERSONNEL REQUIRED

2 technicians

REFERENCES

W. R. Adey and J. P. Meehan. Physiology of Chimpanzees in Orbit. UCLA-USC Joint Experiment on Chimpanzees in Prolonged Orbit, February 1968.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-10

Mouse Biorhythms

EXPERIMENT CATEGORY

Vertebrate Mammalian Biorhythms

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the biorhythms of a small mammal.

MEASUREMENTS AND OBSERVATIONS

Gross body activities
Body temperature
Ambient temperature/pressure
Orientation

DESIRED MISSION DURATION

21 to 30 days (more than 90 days for some studies).

SUBJECTS, MATERIALS, AND EQUIPMENT

6 pocket mice (flight subjects with implant telemeters)
24 pocket mice (total experiment, including backup subjects)
Housing unit (6 animal tubes exclosed in a container)
Implant telemeter receiver
Necropsy kit
Freezer

SPECIAL REQUIREMENTS/REMARKS

Periodic maneuvers, noises, and vibrations should be avoided.

PERSONNEL REQUIRED

1 technician

REFERENCES

C. S. Pittendrigh and R. G. Lindberg. Experiment No. S071: Circadian Rhythm, Pocket Mice. Experimentation Implementation Plan. Northrop Nortronics, Inc., 27 September 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-11

Cockroach Biorhythms

EXPERIMENT CATEGORY

Invertebrate Biorhythms

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the biorhythms of an invertebrate animal. Reproductive cycles of cockroaches will be studied in conjunction with day-night rhythms. Reversal of day-night rhythms may result in the formation of malignancies.

MEASUREMENTS AND OBSERVATIONS

Reproductive cycles and day-night rhythmic behavior
Histologic examinations for possible tumors

DESIRED MISSION DURATION

30 to 90 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Cockroaches (blattidae species), male and female
Insect chambers
Cameras (TV, cine, and still)
Timers
Compound microscope set
Dissecting microscope
Microtome
Histology kit
Micromanipulators
Dissecting kit

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

1 technician .

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-12

Drosophila Pupal Eclosion

EXPERIMENT CATEGORY

Invertebrate Biorhythms

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on a specific biothythmic phenomenon (eclosion of pupae). The rhythm of pupal eclosion has been studied in detail, and a broad data base is available.

MEASUREMENTS AND OBSERVATIONS

Eclosion of pupae
Ambient temperature

DESIRED MISSION DURATION

3 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Drosophila melanogaster pupae (synchronously developing)
Housing chambers, with thermal control units
Eclosion rate counter
TV camera and core memory (if astronaut participation precluded)

SPECIAL REQUIREMENTS/REMARKS

Cyclic environmental stimuli from spacecraft subsystems should be minimized, especially any spacecraft maneuvers with near-24-hour periodicities. No recovery is required.

PERSONNEL REQUIRED

1 technician

REFERENCES

C. S. Pittendrigh and R. G. Lindberg. Experiment No. S072: Circadian Rhythm, Vinnegar Gnat. Experimentation Implementation Plan. Northrop Nortronics, Inc., 27 September 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-13

Capsicum-Seedling and Mature-Plant Biorhythms

EXPERIMENT CATEGORY

Plant Biorhythms

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness and radiation on the biorhythms of the pepper plant (capsicum or phoseolus species). The lima bean is a counterclockwise twiner, and the snap bean has been studied extensively on a clinostat.

MEASUREMENTS AND OBSERVATIONS

Biorhythms ("sleep movements" of leaves, turgor movements resulting from changes in water distribution)
Photosynthesis (degree of lignification)--phaseolus species
Tropism (measure quantized action spectrum, if phaseolus species of relative angle opening of excised bean hook)
Growth of seedlings at germination of seeds
pH of nutrient solution
Radiation dosages

DESIRED MISSION DURATION

90 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Capsicum or phaseolus species, both seed and mature plants
Plant growth chamber (with variable-spectrum light source)
Culture tank (seed and seedling)
Camera (time lapse)
Dosimeter
Radiation shielding
Spectrophotometer (UV and visible)
Electroanalytical apparatus
Freezer

SPECIAL REQUIREMENTS/REMARKS

Phaseolus species may be substituted for capsicum. The entire life cycle of the plant (from seed to mature plant to seed again) should be studied for possible biorhythm modifications.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-14

Avena Biorhythms

EXPERIMENT CATEGORY

Plant Biorhythms

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness and radiation on the biorhythms of oat seeds, seedlings, and mature plants. Treatment with clinostat at terrestrial 1-g level modifies circadian rhythms in plants.

MEASUREMENTS AND OBSERVATIONS

Enzyme assays
Tropisms
Radiation dosages
Biological rhythms
Germination and development

DESIRED MISSION DURATION

90 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Avena seed, seedlings, and mature plants
Plant growth chamber (with variable spectrum light source)
Seed culture tank
Compound microscope
Time-lapse camera
Isotope tracer equipment
Radiation source and shielding
Radiation dosimeter
Microtome
Histrology kit
UV/visible spectrophotometer
Gas chromotograph
Clinostat/centrifuge

SPECIAL REQUIREMENTS/REMARKS

Clinostat treatment appears to interact with radiation sensitivity in a manner interpretable as a shift in the phase of a hypothetical circadian rhythm of sensitivity to radiation. Infrared, ultraviolet, and visible light should be used. Barley or wheat may be substituted for oats.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-15

Genetic Background of Morphologic Adaptation in the Flounder

EXPERIMENT CATEGORY

Vertebrate Genetics

OBJECTIVE AND SIGNIFICANCE

To determine the genetic background of morphologic adaptation in the flounder. The role gravity may play in the normal migration of eye position during growth and the development in the flounder should be discernible by observing effect of gravity-compensation in orbit.

MEASUREMENTS AND OBSERVATIONS

Body orientation, and other behavioral performance
Growth and development

DESIRED MISSION DURATION

60 to 120 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Flounder
Aquarium
Cameras (TV, cine, and still)
Dissecting Kit

SPECIAL REQUIREMENTS/REMARKS

Eye rotation should be studied over several generations of flounder development to observe any changes.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-16

Drosophila Genetics

EXPERIMENT CATEGORY

Invertebrate Genetics

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the genetics of a small invertebrate animal of the insect group (vinegar gnat). Radiation effects also will be studied to determine possible synergism.

MEASUREMENTS AND OBSERVATIONS

Mutation
Brain Cell histology and histochemistry
Mortality rates
Chromosome analysis
Polygenic controlled traits (visual observations):
- Egg productivity
- Survival
- Sex ratios
- Fertility
- Longevity

Enzyme assay (xanthine dehydrogenase activity)
Radiation dosages

DESIRED MISSION DURATION

3 to 14 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Crosophila melanogaster eggs, male first and third instar larvae, and male 3- to 4-day-old pupae
Insect chambers
Radiation source and shielding
Microscope (compound and dissecting)
Isotope tracer equipment
Dosimeter
Cameras (TV, cine, and still)
Refrigerator
Histology kit
Microtome
Dissecting kit
Micromanipulators
Freezer

SPECIAL REQUIREMENTS/REMARKS

Three strains of wild-type vinegar gnats (isogenic) and three heterozygous strains will serve as source material. Males will be used to prevent accidental prerecovery mating. Following package recovery, matings to take place with tester females, with individual "marker" traits to be introduced where necessary. Progeny data will be analyzed.

PERSONNEL REQUIRED

1 technician

REFERENCES

E. C. Keller, Jr. A Study of the Joint Effects of Weightlessness, Genetic Diversity, and Life-Cycle stage on Inherited Traits in Drosophila Melanogaster. NUS Corporation, 16 May 1968.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-17

Amoeba Genetics

EXPERIMENT CATEGORY

Invertebrate Genetics

OBJECTIVE AND SIGNIFICANCE

To determine the existence of spontaneous mutations or other genetic changes resulting from the separate effects of weightlessness and radiation and from their combined, synergistic effects.

MEASUREMENTS AND OBSERVATIONS

Single cell changes
Cytology
Growth and development
Reproductive behavior (cell division)
Mutation rates
Radiation dosages

DESIRED MISSION DURATION

40 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Amoeba species
Culture chambers (radiation-shielded and unshielded)
Radiation source, dosimeters, and shielding
Compound microscope set with camera
Histology kit
Micromanipulators
Microtome
Automatic cell counter
Isotope tracer equipment

SPECIAL REQUIREMENTS/REMARKS

Paramecia may be substituted for studying induction of auxotrophy using techniques of Sonneborne, Hutner, et al.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-18

E. coli Genetics

EXPERIMENT CATEGORY

Microbial Genetics

OBJECTIVE AND SIGNIFICANCE

To determine growth characteristics, spontaneous mutations, and mutation rates in weightlessness and radiation environment to determine extent of any synergistic effects, alteration of mutagenesis, morphogenesis, or other genetic modifications in a well-known species of bacterial microorganism (E. coli).

MEASUREMENTS AND OBSERVATIONS

Visual observation of mutation rates (Frequency of production of auxotrophs; Frequency of production of autibiotic-resistant mutants)
Enzyme assay (Induction of beta-galactosidase by following disappearance of lactose from medium)
Growth lag and log phases (change in generation time)
Metabolic rate (Respiration-O_2 uptake/CO_2 evolution)
DNA/RNA and protein synthesis
Cytology (Mating conjugation and recombination; post-flight observation)
Radiation dosages

DESIRED MISSION DURATION

3 to 7 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Escherichia coli organisms
Bacterial growth chamber
Radiation source, dosimeters, and shielding
Centrifuges (analytical and low speed)
Compound UV microscope set
UV/visible spectrophotometer
Lyophilizer
Polarographic O_2 and CO_2 sensors
Autoclave
Automatic plate scanning counter
Refrigerator
Freezer
Automatic cell counter

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Annual Progress Report. Bioscience Research during Manned Earth-Orbiting Missions, Part Two. 24 October 1966.

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-19

E. coli Lysogenic (T4) Genetics

EXPERIMENT CATEGORY

Microbial Genetics

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness and radiation on the T_4 phase lysogenic process in the bacterial species, Escherichia coli. Lysogeny is a genetic phenomenon which can be acquired by a bacterium after being infected with a virus. The infective T_4 bacteriophage system is one of the best understood genetic systems, at the molecular level.

MEASUREMENTS AND OBSERVATIONS

RNA/DNA kinetics (kinetics of phage DNA synthesis and weight by volume of nucleotides)
Chromosome analysis kinetics of genetic (DNA) recombination
Phage growth and development (mature and recombinant phage density by plaque count)
Metabolite assays by antigen titer of total phage protein, and antigen titer of specific phage protein components.
Radiation dosages

DESIRED MISSION DURATION

3 to 14 days

SUBJECTS, MATERIALS, AND EQUIPMENT

Escherichia coli (K-12 beta strain)
T_4 phage (wild and nII mutants)
Bacterial growth chambers
Radiation source, dosimeters, and shielding
Compound, microscope, with camera (still)
Refrigerator
UV/visible spectrophotometer
Incubator
Autoclave

SPECIAL REQUIREMENTS/REMARKS

Induction of latent virus in bacteria is augmented by ionizing radiation. The T_4 phage/E. coli experiment is adaptable to the use of the flight hardware being developed for the frog egg experiment.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Annual Progress Report. Bioscience Research during Manned Earth-Orbiting Missions, Part Two. 24 October 1966.

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-20

Neurospora Genetics

EXPERIMENT CATEGORY

Microbial Genetics

OBJECTIVE AND SIGNIFICANCE

To study the effect of weightlessness and radiation on mutagenesis in the fungus neurospora crassa, a primitive plant species used extensively in genetic research.

MEASUREMENTS AND OBSERVATIONS

Frequency of production of auxotrophs and other marker mutants; (visual counting)
DNA and RNA formation (kinetics)
Cell division chromosome analyses
Mycelial growth rhythms (cytology and biorhythms)
Reproductive zonation rhythms (reproductive behavior and biorhythms)
Radiation dosages

DESIRED MISSION DURATION

30 to 90 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Neuospora crassa
Culture containers
Neurospora nutrient
Radiation source and dosimeters
Radiation shielding
Centrifuge for control specimens
Histology kit
Automatic cell counter
Microscopes (compound and dissecting) with camera (still)
UV/visible spectrophotometer
Microtome
Micromanipulators
Recorder (potentiometric)

SPECIAL REQUIREMENTS/REMARKS

Neurospora crassa exhibits rhythms in mycelial growth and zonation of reproduction, which are set by time of subculturing and not by time of day.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Annual Progress Report. Bioscience Research during Manned Earth-Orbiting Missions, Part Two. 24 October 1966.

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-21

Teleost Geosensitivity

EXPERIMENT CATEGORY

Vertebrate Geosensitivity

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the ability of a small aquatic vertebrate (teleosts) to orient in water for swimming. Basic information on the evolution of aquatic life and on the emergence of nonaquatic forms may be obtained from uncomplicated observation experiments.

MEASUREMENTS AND OBSERVATIONS

Orientation and gross body activities

DESIRED MISSION DURATION

1 to 2 weeks.

SUBJECTS, MATERIALS, AND EQUIPMENT

Guppies
Aquarium
Cameras (TV, cine, and still)
Dissecting kit
Freezer

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Annual Progress Report. Bioscience Research during Manned Earth-Orbiting Missions, Part Two. 24 October 1966.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-22

Drosophila Geosensitivity

EXPERIMENT CATEGORY

Invertebrate Geosensitivity

OBJECTIVE AND SIGNIFICANCE

To study the locomotor response of an invertebrate of the insect group (drosophila species) to weightlessness. Response to gradients of light in locomotion should be observed, as well as thigmotactic responses.

MEASUREMENTS AND OBSERVATIONS

Behavioral performance (locomotion, before and after removal of halteres, wings)
Body orientation
Gross body activities
Thigmotropic responses

DESIRED MISSION DURATION

3 to 14 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Drosophila melanogaster, adult males and females
Drosophila facility
Micromanipulators
Dissecting microscope
Cameras (TV, cine, and still)
Dissecting kit

SPECIAL REQUIREMENTS/REMARKS

Drosophila are adapted to 1 g; their reaction to weightlessness should be instructive. If halteres are present, their removal in orbit may be instructive. The effect of wing removal should be studied.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-23

Capsicum Tropisms

EXPERIMENT CATEGORY

Plant Geosensitivity

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the tropic responses of the pepper plant (capsicum species). Initial orbital experiments have indicated a similar response to results of terrestrial-based horizontal clinostat studies. Longer-duration orbital experiments are required to confirm the short-range effects.

MEASUREMENTS AND OBSERVATIONS

Plant orientation (leaf curvature) (liminal angle between ventral side of leaf and stem)
Metabolite assays (analyses of leaves and stems for sucrose, starch, and free amino acids
Tropisms
Radiation doseages

DESIRED MISSION DURATION

90 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Capsicum species
Plant growth chamber
Centrifuge/clinostat
Camera (time-lapse)
Radiation shielding
UV/visible spectrophotometer

SPECIAL REQUIREMENTS/REMARKS

Phaseolus species may be substituted for capsicum. An orbital study of geo-sensitivity that covers the entire life cycle of the plant (from seed to mature plant to seed again) would be of great interest. An orbiting combined centrifuge/clinostat should be used for strict control with ground-based studies.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

J. C. Finn, Jr. and S. P. Johnson. Liminal Angle of a Plagiogeotropic Organ under Weightlessness. Biological Experiments in Space. North American Aviation, Inc., 31 October 1962.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-24

Root and Shoot Tropisms

EXPERIMENT CATEGORY

Plant Geosensitivity

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on avena root and shoot tropisms, and to determine if there is any significant difference between the effect of weightlessness and the effect of horizontal clinostat at Earth's surface (1 g). Exposures to infrared, ultraviolet, visible light, and dark chamber should be studied.

MEASUREMENTS AND OBSERVATIONS

Metabolite and enzyme assays: determine auxin distributions (basi-petal transport); determine enzyme distributions
Orientation (determine curvatures of the coleoptile)
Tropisms

DESIRED MISSION DURATION

90 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Avena seeds, seedlings, and mature plants
Plant growth chamber (with variable spectrum/light source)
Seedling culture tank
Seed culture tank
Clinostat/centrifuge
Time-lapse camera

SPECIAL REQUIREMENTS/REMARKS

A complete life cycle (from seed to mature plant to seed again) should be studied in weightlessness. Wheat and barley seed, roots, and shoots may be substituted for oats. Both chemotropic and geotropic aspects should be studied for their interrelationships.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

H. M. Conrad. Biochemical Changes in the Developing Wheat Seedling in the Weightless State. Resources Planning and Control Corporation, May 1968.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-25

Human Cells Geosensitivity

EXPERIMENT CATEGORY

Geosensitivity

OBJECTIVE AND SIGNIFICANCE

To determine the sensitivity of single living human cells to gravity compensation in Earth orbit. Various cell functions and structural features will be analyzed to determine possible alterations.

MEASUREMENTS AND OBSERVATIONS

Cytology (pinocytosis, cell size, organelle size, and motion)
Metabolite assays and biochemical determinations, including radioactive isotope assays and enzyme reaction studies.)
Cell orientation
Growth and development
Cell division (mitosis)

DESIRED MISSION DURATION

14 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Human cells (normal and abnormal, including fibrocytes, blood cells, hela cells, and other tumor cells, both benign and malignant)
Human cell flight experiment package*
UV-visible spectrophotometer
Dissecting microscope
Mass measurement device (micro)
Isotope tracer equipment
Refrigerator
Freezer

SPECIAL REQUIREMENTS/REMARKS

Histochemical and biochemical determinations are presently scheduled for post-flight. Technician must focus a low- and high-power microscope on cells in a short period.

*Package includes Microscope-camera system (40x camera, 20x camera); microscope with phase contract optics and adjustable focus; biopack system (four identical biopack subsystems); temperature control system; canister.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-26

Primate Hemodynamics

EXPERIMENT CATEGORY

Vertebrate Hemodynamics

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the hemodynamics of a near-human mammal. Much information can be obtained on circulatory dynamics during a prolonged flight using well-instrumented, medium-size primates. Direct microscopic observations of the microcirculation would be valuable if the equipment can be adapted into the macaque modular configuration. The primate radiation experiment covers the hemotologic aspects (Experiment 3-49).

MEASUREMENTS AND OBSERVATIONS

Heart rate and ECG
Arterial and venous pressures
Intracardiac pressures and pO_2
Aortic pressure and pO_2
Plasma volume, RBC mass
Body mass
Temperature
Respiration rate
Metabolic rate, O_2 consumption
Bone density
Calcium, nitrogen balance
Blood and urine pH
Food and fluid balance
Corneal capillary flow
Cardiac output

DESIRED MISSION DURATION

60 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 adult monkeys (M. nemestrina)
Automated primate lab module and collection subsystems
Binocular microscope (dissecting)
Bond densitometer
Mass measurement devices (macro and micro)
Radioisotopic tracers
Cameras (still)
Exerciser/ergometer
Organism centrifuge (large)
Animal restraints
UV-visible spectrophotometer
Electroanalytical apparatus
pO_2 and pCO_2 sensors
Dissecting kit
Freezer

SPECIAL REQUIREMENTS/REMARKS

One electrode of ECG telemetry unit imbedded in crest of ilium, and the other sutured to base of diaphragm, serve as a myogram of diaphragmatic contraction, and, thus, a record of respiratory activity. Closely correlated with Experiment 3-27.

PERSONNEL REQUIRED

1 technician

REFERENCES

Automated Primate Research Laboratory Proposal. McDonnell Astronautics Company Report Nos. F557, F583, and F681, November 1966.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-27

Primate Metabolism

EXPERIMENT CATEGORY

Vertebrate Metabolism

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on metabolic parameters of a near-human mammal. Much information can be obtained on respiration, water balance, and many other facets of the total mass/energy exchange interactions during a prolonged flight by using well-instrumented medium-size primates.

MEASUREMENTS AND OBSERVATIONS

- Heart rate and ECG
- Arterial and venous pressures
- Intracardiac pressures and pO_2
- Aortic pressure and pO_2
- Plasma volume, RBC mass
- Body mass
- Temperature
- Respiratory rate
- Gross body activities
- Metabolic rate, O_2 consumption
- Bone density
- Calcium, nitrogen balance
- Blood and urine pH
- Food and fluid balance
- Corneal capillary flow
- Cardiac output
- Body water
- Total blood volume

DESIRED MISSION DURATION

60 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

- 2 adult monkeys (M. nemestrina)
- Automated primate lab module and collection subsystems
- Binocular microscope, dissecting
- Bone densitometer
- Mass measurement devices (macro and micro)
- Radioisotopic tracers
- Exerciser/ergometer
- Freezer
- Camera (still)
- Organism centrifuge (large)
- Animal restraints
- UV-visible spectrophotometer
- Electroanalytical apparatus
- pO_2 and pCO_2 sensors
- Dissecting kit

SPECIAL REQUIREMENTS/REMARKS

Can be integrated with Experiment 3-26.

PERSONNEL REQUIRED

2 technicians

REFERENCES

Automated Primate Research Laboratory Proposal. McDonnell Astronautics Company Report Nos. F557, F583, and F681, November 1966.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-28

Mouse Metabolism

EXPERIMENT CATEGORY

Vertebrate Metabolism

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the metabolic acitivites of a small mammal (mice or rats).

MEASUREMENTS AND OBSERVATIONS

Heart rate
Respiratory rate
Food intake/waste output
Calcium balance
Nitrogen balance
Electrolyte balance
Body temperature
Metabolic rate
Gross body activities
Body mass
Total body water
Urine and fecal analyses
Organ masses
Skeletal mass
Bone density

DESIRED MISSION DURATION

30 to 60 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

100 to 200 mice (or rats)
Animal housing facility
Exerciser/ergometer
Compound microscope set
Mass measurement devices (macro and micro)
Gas chromatograph
Centrifuges (analytic and low speed)
Infrared spectrophotometer
Mass spectrometer
UV-visible spectrophotometer
Timer
Bone densitometer
Necropsy kit
Electrophoresis apparatus
Recorder (potentiometric)
Electroanalytical apparatus
Radioisotope tracer
Camera (still)
Freezer
Lyophilizer

SPECIAL REQUIREMENTS/REMARKS

Some animals will be sacrificed and examined during orbital flight. Others will be returned to Earth and studied. Waste filters may be removed, preserved, and analyzed on return to Earth.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

L. T. Kail. Study of an Animal Research Facility (Using S-IVB) for a Manned Orbital Biotechnology Laboratory. Douglas Report No. DAC-58039, September 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-29

Daphnia Metabolism

EXPERIMENT CATEGORY

Invertebrate Metabolism

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the metabolism of a small aquatic invertebrate animal with a calcium-containing chitinous exoskeleton. Daphnia pulex are extremely sensitive to toxic materials and could serve as biological monitors of atmospheric contaminants.

MEASUREMENTS AND OBSERVATIONS

Carbon, calcium, phosphorus, and nitrogen balance
O_2 uptate, CO_2 output (metabolic rate)
Toxic effects (organ histology and histochemistry)
Growth and development
Radiation dosages
Electrolyte balance

DESIRED MISSION DURATION

30 days. (A 14-day experiment will permit three successive generations.)

SUBJECTS, MATERIALS, AND EQUIPMENT

Daphnia pulex (fresh water flea)
Daphnia container cylinders
Chlamydomonas algae (food source)
Respiration (calorimetry) chambers
Physiological gas analyzer (electroanalytical apparatus)
Radiation shielding
Isotope tracer equipment
Microscopes (compound and dissecting)
Histology kit
Micromanipulators
Microtome
Dissecting kit

SPECIAL REQUIREMENTS/REMARKS

Metabolic requirements of shielded and unshielded animals and movement of calcium in exoskeleton will be studied. Presence and effects of free radicals produced by radiation may be detectable because of the daphnia's sensitivity to toxic substances.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

Penetration of Calcareous Substrates by Invertebrates and Lower Plants. Scheduled International Symposium; AAAS Meeting, Dallas, Texas, December 1968.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-30

Drosophila Metabolism

EXPERIMENT CATEGORY

Invertebrate Metabolism

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the metabolism of an invertebrate animal of the insect group (drosophila). Assays of enzyme activities and electrophoretic mobilities associated with carbohydrate and protein metabolism should serve as reliable biochemical end points.

MEASUREMENTS AND OBSERVATIONS

Xanthine dehydrogenose activity by fluormetry (enzyme assay)
Enzyme (electrophoresis)
Purine catabolism (paper chromatography)
Metabolic rate (pO_2 uptake, CO_2 generation)

DESIRED MISSION DURATION

3 to 14 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Drosophila melanogaster adults, eggs, larvae, and pupae
Drosophila facility with incubator
Dissecting microscope
Micromanipulators
Dissecting kit
Insect respirometer (CO_2 and O_2 sensors)
Lyophilizer
Freezer

SPECIAL REQUIREMENTS/REMARKS

Effective screening system for the assay of biochemical end points involves a three-dimensional chromatographic technique. Vinegar gnats may be returned to Earth for laboratory analyses of biochemical end points.

PERSONNEL REQUIRED

1 technician

REFERENCES

E. C. Keller, Jr. A Study of the Joint Effects of Weightlessness, Genetic Diversity, and Life-Cycle Stage on Inherited Traits in Drosophila Melanogaster. NUS Corporation, 16 May 1968.

Biological Experiments in Space. North American Aviation. Inc., June 1963.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-31

Crown Gall Metabolism

EXPERIMENT CATEGORY

Plant Metabolism

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness and radiation on the metabolism of a plant tumor of bacterial origin (cacus species) and to conduct clinostat experiments on the metabolism of a plant tumor of bacterial origin. Clinostat experiments on Earth have indicated that gravity-compensation results in an increased size (thereby presumably increasing metabolism) of the tumor.

MEASUREMENTS AND OBSERVATIONS

Assimilation of various plant metabolities of the crown gall tumor cells (metabolic assay)
Radiosiotope tracer assays of plant metabolites
Microscopic observations of tumor growth, cell divisions, cell size (cytology)
Plant respiration and tumor metabolism (metabolic rate)

DESIRED MISSION DURATION

90 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Dacus species
Agrobacterium tumefaciens
Auxin (indolyl-3-acetic acid)
Plant growth chamber (unshielded)
Tissue culture equipment
Radiation source and dosimeters
Histology kit
Compound microscope
Microtome
Plant respirometer (O_2 and CO_2 sensors)
Clinostat/centrifuge
Radiation shielding
Isotope tracer equipment

SPECIAL REQUIREMENTS/REMARKS

Tobacco or tomato plants and virus or nematode parasites may be substituted for the carrot/bacterial tumor system.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

A. C. Braun and H. N. Wood. The Plant Tumor Problem. Advances in Cancer Research, 1961, Pages 81-109.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-32

Avena Metabolism

EXPERIMENT CATEGORY

Plant Metabolism

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness and radiation on the metabolism of seed, seedlings, and mature oat plants.

MEASUREMENTS AND OBSERVATIONS

Seed germination
Uptake and distribution of radioactive-labeled metabolites (metabolic rate)
Increase in cell mass and individual cell size (cytology)
Differentiation rate (development)
Growth cycle
Photosynthetic rate
Biochemical and histochemical assays of enzymes (organ histochemistry and enzyme assay)
Phosphate esterification (cytochemistry)
CO_2 fixation (photosynthesis)
Radiation dosages

DESIRED MISSION DURATION

90 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Avena seed, seedlings, and mature plants
Plant growth chambers
Seed culture tanks
Seedling culture tanks
Clinostat/centrifuge
Compound microscope
Time-lapse camera
Histology kit
Radiation source, shielding, and dosimeters
Microtome
Isotope tracer equipment
Plant respirometer (CO_2 and O_2 sensors)
UV/visible spectrophotometer
Gas chromatograph
Potentiometric recorder

SPECIAL REQUIREMENTS/REMARKS

Barley or wheat may be substituted for oats. Infrared, ultraviolet, and visible light sources, as well as dark chamber effects, should be studied.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

H. M. Conrad. Biochemical Changes in the Developing Wheat Seedling in the Weightless State. Resources Planning and Control Corporation, May 1968.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-33

Dinoflagellate Metabolism

EXPERIMENT CATEGORY

Invertabrate Metabolism

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on luminescence, photosynthesis, cell division, and other metabolic functions of a unicellular invertebrate animal (dinoflagellatae).

MEASUREMENTS AND OBSERVATIONS

Luminescence
Photosynthesis
Growth and development
Cytology
Metabolic rate
Radioautography uptake
Cell division (number counting of populations)
Enzyme and metobolite assays (concentration of ATP, luciferin, luciferase)

(DESIRED MISSION DURATION

90 to 120 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Gonyaulax polyedra (dinoflagellatae)
Compound microscope set
Protozoan growth chambers
Automatic cell counter
UV/visible spectrophotometer
Cameras (TV, cine, and still)
Microtome
Radioactive isotopes and tracer equipment
Histology kit
Potentiometric recorder

SPECIAL REQUIREMENTS/REMARKS

Rhythms in luminescence, photosynthesis, and cell division can be entrained by alterations in light-dark cycles, by light quality, and by temperature.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Annual Progress Report. Bioscience Research during Manned Earth-Orbiting Missions, Part Two. 24 October 1966.

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-34

Neurospora Metabolism

EXPERIMENT CATEGORY

Microbial Metabolism

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the metabolism of the fungus Neurospora crassa. This primitive plant species has been used extensively, especially in genetic research.

MEASUREMENTS AND OBSERVATIONS

Metabolic rate (rate of assimilation of C^{14}-labeled substrates into specific metabolic intermediates)
Metabolite assays and electrolyte balance (electrophoretic mobility of spores, to indicate surface charges resulting from metabolic processes)
Zonation of reproduction by visual observation (cytology) and time-lapse photography. Also measure density of mycelia (cell division). Measure dry weights for growth and development. Determine spore germination, using both conidia and ascospores
Radiation dosage

DESIRED MISSION DURATION

30 to 90 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Culture containers
Spore filter
C^{14} radioisotopes and tracer apparatus
Radiation source, shielding, and dosimeters
Centrifuge for control specimens
Microtome
Automatic cell counter
UV/visible spectrophotometer
Micromanipulator
Dissecting microscope
Mass measuring device (micro)
Microscope with still camera
Timer
Respirometer (O_2 and CO_2 sensors)
Autoclave
Electrophoresis apparatus with optical densitometer and recorder

SPECIAL REQUIREMENTS/REMARKS

Neurospora crassa exhibits rhythms in mycelial growth and zonation of reproduction, which are set by time of subculturing and not by time of day.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Annual Progress Report. Bioscience Research during Manned Earth-Orbiting Missions, Part Two. 24 October 1966.

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-35

Frog Egg Morphogenesis

EXPERIMENT CATEGORY

Vertebrate Morphogenesis

OBJECTIVE AND SIGNIFICANCE

To determine effect of weightlessness on sequentially exposed unfertilized eggs, fertilized eggs, and embryos of a vertebrate animal (frog eggs - rana pipiens). Significance lies in the sensitivity and responsiveness to environmental conditions and changes of the rapidly dividing and differentiating biological system organizational level of frog eggs.

MEASUREMENTS AND OBSERVATIONS

Observe eggs before, during, and after fertilization by sperm (cell division).
Temperature
Gross and microscopic study of fixed (in orbit) specimens to observe differentiation and development (histochemistry).
Enzyme and metabolate (physiological studies to be implemented by tracer methodology).

DESIRED MISSION DURATION

4 1/2 hours. (If longer missions required, all embryos can be fixed and returned up to 2 weeks after launch. An experiment longer than 3.25 days requires additional flight facilities.)

SUBJECTS, MATERIALS, AND EQUIPMENT

Frog eggs (rana pipiens)
3 flight hardware packages, consisting of 12 modules each, one module comprised of 3 units.
Compound microscope with camera
Refrigerator

SPECIAL REQUIREMENTS/REMARKS

Launch hold-time should be minimal, since eggs are most sensitive to gravity effects just prior to the first cell division. G-levels should be kept as low as possible, especially during initial hours of post-launch. Temperature critically affects the rate and normality of development.

PERSONNEL REQUIRED

1 technician

REFERENCES

J. W. Tremor and R. S. Young. The Effect of Subgravity on the Frog Egg, Fertilized and Developing in Space. 11 December 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-36

Fish Morphogenesis

EXPERIMENT CATEGORY

Vertebrate Morphogenesis

OBJECTIVE AND SIGNIFICANCE

To determine the possible changes in the development of small, rapidly reproducing fish in weightlessness. After a number of generations, any morphological changes that might occur would be significant from an evolutionary standpoint.

MEASUREMENTS AND OBSERVATIONS

Growth rate
Tissues and organ changes

DESIRED MISSION DURATION

60 to 120 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Guppies (or species of Caribbean bone-fish)
Aquarium
Cameras (TV and cine)
Compound microscope
Histology kit
Microtome
Mass measuring device (macro)
Dissecting kit
Refrigerator
Freezer

SPECIAL REQUIREMENTS/REMARKS

None.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Annual Progress Report. Bioscience Research during Manned Earth-Orbiting Missions, Part Two. 24 October 1966.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-37

Daphnia Morphogenesis

EXPERIMENT CATEGORY

Invertebrate Morphogenesis

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the growth and development of an invertebrate aquatic animal (water flea). Since there may be morphological changes in head shape in response to water turbulence, it may be possible to separate the effects of launch vibrations from the effects of weightlessness.

MEASUREMENTS AND OBSERVATIONS

Gross body activity
Head shape (ratio head/body lengths)
Cytology (cellular map of exoskeleton)
pCO_2
Radiation dosage
pH
Number of eggs/brood; embryological stage (cell division); condition
Histology (ovary condition, birth defects, tumors)
Number of young (per brood group)
Survival
pO_2

DESIRED MISSION DURATION

4 to 30 days. (A 14-day experiment will permit three successive generations.)

SUBJECTS, MATERIALS, AND EQUIPMENT

Daphnia pulex (12 pregnant females)
3 container cylinders
Chlamydomonas (algae food)
Polorographic sensors
Microscopes (compound and dissecting)
Dosimeter
Camera (still)
Incubator
Freezer

SPECIAL REQUIREMENTS/REMARKS

Radiation damage may also be recorded by lost or abnormally proliferated cells as revealed in markings on the shed exoskeletons. The algae food source required for prolonged flight of the experiment would serve as a study of a closed ecological system in weightlessness. Since the animals are transparent, they are easily examined for defects, tumors, etc.

PERSONNEL REQUIRED

1 technician

REFERENCES

F. B. Taub. Space Flight Effects on Daphnia Embryology and Growth. Food Sciences Division, College of Fisheries, University of Washington.

Daphnia Growth and Reproduction Studies. NASA Report No. NSG-519, 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-38

Flatworm Morphogenesis

EXPERIMENT CATEGORY

Invertebrate morphogenesis

OBJECTIVE AND SIGNIFICANCE

To study the growth and development of an invertebrate of the free-living flatworm group, with both asexual and sexual modes of reproducting under weightlessness. In sexual reproduction, development from egg to adult form is direct, without a larval stage. Asexual reproduction is by transverse fission.

MEASUREMENTS AND OBSERVATIONS

Reproduction and development
Gross body activities
Organ histology

DESIRED MISSION DURATION

45 to 90 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Planaria (dugesia)
Aquaria
Miscroscope observation chambers
Food (lyophilized sterile liver hemogenates)
Microscopes (compound and dissecting)
Cameras (TV and cine)
Histology kit
Microtome
Micromanipulators
Dissecting kit
Organism centrifuge (small)
Timer

SPECIAL REQUIREMENTS/REMARKS

Population growth characteristics may be studied from the ecological standpoint, under weightlessness. Some of the experiments on transfer of "light memory" may be repeated in orbit.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Annual Progress Report. Bioscience Research during Manned Earth-Orbiting Missions, Part Two. 24 October 1966.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEST REF NO. 3-39

Drosophila Morphogenesis

EXPERIMENT CATEGORY

Invertebrate Morphogenesis

OBJECTIVE AND SIGNIFICANCE

To study the sequential development of all life stages of the vinegar gnat under weightlessness. The inclusion of the various life cycles should clarify the extent and timing of spermatogonial changes and reveal whether a total life cycle is capable of completion in weightlessness.

MEASUREMENTS AND OBSERVATIONS

Growth and development of eggs, larvae, pupal, and adults
Histology (microscopic observations of spermatogonia)
Measurements of life span (aging), including time span of each stage in life cycle

DESIRED MISSION DURATION

3 to 14 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Drosophila melanogaster, adult males and females
Drosophila melanogaster, male eggs, first and third instar larvae
Drosophila melanogaster, male pupal
Drosophila facility with incubator
Compound microscope
Dissecting microscope
Histology kit
Freezer
Cameras (TV and cine)
Micromanipulators
Microtome
Dissecting kit

SPECIAL REQUIREMENTS/REMARKS

Attempt should be made to promote mating of adult flies in orbit.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

E. C. Keller, Jr. A Study of the Joint Effects of Weightlessness, Genetic Diversity, and Life-Cycle Stage on Inherited Traits in Drosophila Melanogaster. NUS Corporation, 16 May 1968.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-40

Crown Gall Morphogenesis

EXPERIMENT CATEGORY

Plant Morphogenesis

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness and radiation on the growth of a plant tumor of bacterial origin (daucus species). Clinostat experiments on Earth have indicated that gravity-compensation allows an increased growth of the tumor.

MEASUREMENTS AND OBSERVATIONS

Histochemistry (transformation of auxin-conditioned host cells into tumor cells)
Development or continuous autonomous proliferation of transfored cells into a neophastic growth
Microscopic observations of cell size and structure, chromosomes, etc.
Cytology (gross observations of tumor size and shape)
Radiation dosages

DESIRED MISSION DURATION

90 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Daucus species
Agrobacterium tumefaciens
Auxin (indolyl-3-acetic acid)
Tissue culture equipment
Plant growth chamber (unshielded)
Plant growth chamber (radiation-shielded)
Radiation source and dosimeters
Clinostat/centrifuge
Compound microscope
Histology kit
Microtome

SPECIAL REQUIREMENTS/REMARKS

Tobacco or tomato plants and virus or nematode parasites may be substituted for the carrot/bacterial tumor system.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

A. C. Braun and H. N. Wood. The Plant Tumor Problem. Advances in Cancer Research, 1961, Pages 81-109.

EXPERIMENT REQUIREMENT SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-41

Avena Morphogenesis

EXPERIMENT CATEGORY

Plant Morphogenesis

OBJECTIVE AND SIGNIFICANCE

To determine the effect of space environment on the growth and development of oat seed, seedlings, and mature plants. A complete life cycle from seed through mature plant to seed again should be studied.

MEASUREMENTS AND OBSERVATIONS

Life cycle completion
Organogenesis (seed germination and development)
Growth and development

DESIRED MISSION DURATION

90 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Avena seed, seedlings, and mature plants
Plant growth chamber
Plant nutrients
Seedling culture tank
Seed culture tank
Compound microscope
Histology kit
Centrifuge/clinostat
Microtome
Time-lapse camera

SPECIAL REQUIREMENTS/REMARKS

Wheat or barley may be substituted for oats. Infrared, ultraviolet, and visible light exposures, as well as dark chamber effects, should be studied.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

H. M. Conrad. Biochemical Changes in the Development Wheat Seedling in the Weightless State. Resources Planning and Control Corporation, May 1968.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-42

Amaranthus Morphogenesis

EXPERIMENT CATEGORY

Plant Morphogenesis

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on the germination potential of the pigweed. Seeds of amaranthus exhibit a definite periodicity in germination potential; each cycle is approximately 12 months long, and cycles may persist for many years.

MEASUREMENTS AND OBSERVATIONS

Germination of seeds
Displacements in germination phase.
General growth and development root and stem curvatures.

DESIRED MISSION DURATION

1 year or more

SUBJECTS, MATERIALS, AND EQUIPMENT

Amaranthus retroflexus seeds
Plant growth chamber
Seed culture tank with seed germination set-ups (e. g. , gridded blotting paper)
Seedling culture tank
Camera (lapse-time)

SPECIAL REQUIREMENTS/REMARKS

Longevity of amaranthus seeds is 40 to 50 years. Displacement in germination phase may indicate a gravity-linked time mechanism. Use seeds obtained from plants artificially matured at different times of year on Earth to provide seeds of possible displaced phase.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

Role of Gravitational Stress in Land Plant Evolution and the Gravitational Factor in Lignification. University of Hawaii (Contract No. NASw-767).

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-43

Amoeba Morphogenesis

EXPERIMENT CATEGORY

Invertebrate Morphogenesis

OBJECTIVE AND SIGNIFICANCE

To compare the distribution and concentration of organelles (e. g. , mitochondria, golgi apparatus, vacuoles, granules, and protoplasmic zones) and other cytologic structures in weightlessness. Cell division and enzyme localization may be studied and compared with ground-control cultures.

MEASUREMENTS AND OBSERVATIONS

Cytology and body activity (microscopic observation of single cells; e. g. , protoplasmic streaming and pseudopodial movement)
Growth and division rate
Enzyme localization
Number of nuclei and morphology (chromosome analysis)
Radiation dosage

DESIRED MISSION DURATION

40 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Amoeba species
Culture containers
Radiation source, dosimeters and shielding
Compound microscope
Dissecting microscope
Cameras (cine and still)
Incubator
Organism centrifuge (small)
Micromompulators
Micro-ome
Histology Kit
Automatic cell counter
Refrigerator
Freezer

SPECIAL REQUIREMENTS/REMARKS

Morphogenetic studies to use a continuous culture process (chemostat and finger pump) to maintain constant environment per organism.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Annual Progress Report. Bioscience Research during Manned Earth-Orbiting Missions, Part Two. 24 October 1966.

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-44

Bromeliad Morphogenesis

EXPERIMENT CATEGORY

Plant Morphogenesis

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness on an epiphytic plant of the bromeliad group. Tillandsia species of the Spanish-moss-type subsist on atmospheric nutrients and water, requiring no soil substrate. The growth pattern at 1-g (Earth) is in the form of pendant streamers.

MEASUREMENTS AND OBSERVATIONS

Growth and development, especially orientation of "streamers" (tropism)
Metabolic rate (CO_2 uptake, O_2 evolution)
Water and nutrient metabolism
Photosynthesis light requirements

DESIRED MISSION DURATION

90 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Spanish moss species (tillandsia usneoides)
Plant growth chamber with nutrient atmosphere and variable-spectrum
Camera (still)
CO_2 and O_2 sensors

SPECIAL REQUIREMENTS/REMARKS

The potential nutrient and/or bioregenerative capacities of Spanish moss may be studied. Another genus of the bromeliads (deuterocohnia meziana) has a flower scape that develops a cambium layer, a phenomenon practically unknown in other monocotyledonous plants.

PERSONNEL REQUIRED

1 technician

REFERENCES

Role of Gravitational Stress in Land Plant Evolution and the Gravitational Factor in Lignification. University of Hawaii (Contract No. NASw-767).

R. G. Wilson and C. Wilson. Bromeliads in Cultivation, Vol. I. Hurricane House Publishers, Inc., Coconut Grove, Florida, 1963.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-45

Crown Gall Parasitism

EXPERIMENT CATEGORY

Plant Parasitism

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness and radiation on a typical plant/parasite system (daucus species), with emphasis on induction time changes and any biorhythm effects, such as altered mitotic division rates. Clinostat experiments on Earth have indicated a gravity-compensation acceleration of tumor growth.

MEASUREMENTS AND OBSERVATIONS

Cell division (frequency, aberrations, etc.)
Tumor size and shape (cytology)
Induction periods, mitotic phases, light-dark effects
Radiation dosage
General growth development

DESIRED MISSION DURATION

90 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Daucus species
Agrobacterium tumefaciens
Auxin (indolyl-3-acetic acid)
Plant growth chamber (unshielded)
Plant growth chamber (radiation-shielded)
Radiation source and dosimeters
Radioactive isotopes and tracer equipment
Tissue culture equipment
Compound microscope
Dissecting microscope
Microtome
Histology Kit

SPECIAL REQUIREMENTS/REMARKS

Tobacco or tomato plants and virus or nematode parasites may be substituted for the carrot/bacterial tumor system.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

A. C. Braun and H. N. Wood. The Plant Tumor Problem. Advances in Cancer Research, 1961, Pages 81-109.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-46

Spontaneous and Induced Mouse Leukemia

EXPERIMENT CATEGORY

Parasitism

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness and radiation on the development rates of spontaneous and induced mouse leukemia. The effect of day-night radiation sensitivity will be included.

MEASUREMENTS AND OBSERVATIONS

- Hematologic cell counts (including bone-marrow examination by radioactive isotope tracer studies)
- Cell mitoses
- Chromosome analyses
- Histopathologic examination (microscopic) of tissues, including lymph nodes and thymus
- Enzyme concentrations of blood cells and tissues
- Tumor virus induction times
- Development of tumors
- Total body mass
- Hemoglobin
- Total plasma proteins
- Organ mass
- Radiation dosages

DESIRED MISSION DURATION

1 year or more.

SUBJECTS, MATERIALS, AND EQUIPMENT

- Laboratory mice, of low and high leukemia incidence
- Mouse facility
- Leukemogenic and tumor-inducing viruses
- Centrifuge (analytic, refrigerated)
- Automatic cell counter
- Radiation source, dosimeters, and shielding
- Microscopes (compound and dissecting)
- Microtome
- Dissecting kit
- Histology kit
- Electrophoresis apparatus
- Electroanalytical apparatus
- Polarographic CO_2 and O_2 sensors
- Tissue culture equipment
- Organism centrifuge (small)
- Freezer
- Mass spectrometer
- Infrared spectrophotometer
- UV/visible spectrophotometer
- Gas chromatograph
- Micromanipulators
- Isotope tracer equipment

SPECIAL REQUIREMENTS/REMARKS

Strict isolation rules should be observed to prevent possible spread of virus. The polyoma virus is difficult to handle from this standpoint. Electron microscope may be feasible only for an Earth-based laboratory.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. *Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station.* 15 December 1967.

Operation Shotmouse. Military Medicine 119, 1956, Page 151.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-47

Amoeba Parasitism

EXPERIMENT CATEGORY

Invertebrate Parasitism

OBJECTIVE AND SIGNIFICANCE

To study the life histories of the endamoeba species (periplaneta Americana) system in weightlessness. An alternate experiment would involve study of flagellated protozoan parasites (or symbionts) in guts of termites.

MEASUREMENTS AND OBSERVATIONS

Histology (microscopic observations of guts of cockroaches or termites)
Cayalogy (observe for possible amebic cyst forms)
Fecal analysis (of host organism)
Growth and development

DESIRED MISSION DURATION

40 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Amoeba (endamoeba species)
American cockroaches (periplaneta Americana), males and females
(alternate host/parasite species: flagellated protozoan species in guts of termite hosts)

Insect chambers and food systems	Microtome
Compound microscope with camera	Organism centrifuge (small)
Dissecting microscope	Freezer (-20°C)
Micromanipulators	Refrigerator (5°C)
Histology kit	Incubator

SPECIAL REQUIREMENTS/REMARKS

Flagellated protozoa in guts of termites may, in weightlessness, change from symbiotic to parasitic habits. If flagellated forms of protozoa are utilized (in termite guts), effects of weightlessness on flagellar motion should be observed.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Annual Progress Report. Bioscience Research during Manned Earth-Orbiting Missions, Part Two. 24 October 1966.

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-48

Human Cell Reproduction

EXPERIMENT CATEGORY

Reproduction

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness and radiation on dividing human cells in culture. It may be possible to gain information on cell aging by studying division rates and division number in the gravity-compensated environment. The role of radiation effects on cell aging may also be studied for possible synergism.

MEASUREMENTS AND OBSERVATIONS

Mitotic cycles
Chromosome analyses (karyotyping)
Mutation rates by observations for possible malignant transformations
Biochemical and histochemical analyses of cells
Radiation dosages (ambient)
General growth and development

DESIRED MISSION DURATION

30 to 60 days; 90 days or more for biorhythm observations.

SUBJECTS, MATERIALS, AND EQUIPMENT

Human cells (normal fibroblasts)
Benign and malignant tumor cells
Cell culture chamber
Cell culture chamber storm cellar
Refrigerated storm cellar
Cameras (still and cine)
Compound Microscope
Microtome
Histology kit
Radiation dosimeters and shielding

SPECIAL REQUIREMENTS/REMARKS

Terrestrial human cells in culture apparently have a limitation of approximately 50 cell divisions (normal nontransformed fibroblasts). If extra energy should be available to the cell in weightlessness, it may be available to repair irradiation damage.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

Report on the Development of the MORL System Utilization Potential. Douglas Report No. SM-48808.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 3-49

Primate Radiation

EXPERIMENT CATEGORY

Vertebrate Reproduction

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness and radiation on primates, especially during periods of intense solar-flare activity. Day-night variations in radiations sensitivity should be studied. Some primates with prior terrestrial radiation exposures could be studied as well as some with onboard radiation exposures.

MEASUREMENTS AND OBSERVATIONS

Heart rate and ECG
Arterial and venous pressures
Intracardiac pressures and pO_2
Aortic pressure and pO_2
Plasma volume, RBC mass
Body mass
Temperature
Respiratory rate
Skeletal mass
Organ mass
Metabolic rate, O_2 consumption
Bone density
Calcium, nitrogen balance
Blood and urine pH
Food and fluid balance
Corneal capillary flow
Cardiac output
Urinalysis
Total body water
Organ histology
Radiation doses

DESIRED MISSION DURATION

1 year or more.

SUBJECTS, MATERIALS, AND EQUIPMENT

2 adult monkeys (M. nemestrina)
Automated primate lab module and collection subsystems
Dissecting microscope
Bone densitometer
Mass measurement devices (macro and micro)
Radioisotopic tracers
Exerciser/ergometer
Frozen sample storage
Microtome
Camera (still)
Histology kit
Organism centrifuge (large)
Animal restraints
V/visible spectrophotometer
Electroanalytical apparatus
pO_2 and pCO_2 sensors
Radiation source, shielding, and dosimeters
Dissecting kit

SPECIAL REQUIREMENTS/REMARKS

Effects of selected radioactive isotopes on chromosomes over an extended period in weightlessness should be studied. Electron microscope may be feasible only for an Earth-based laboratory.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Final Progress Report. Bioscience Research during Earth-Orbiting Missions: Manned Orbital Space Station. 15 December 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT — TEXT REF. NO. 3-50

Flatworm Regeneration

EXPERIMENT CATEGORY

Invertebrate Reproduction

OBJECTIVE AND SIGNIFICANCE

To determine the effect of weightlessness and radiation on tissue regenerative capabilities of the invertebrate flatworm. Since basic protoplasmic processes of repair and redifferentiation are involved. This investigation should bear some relationship to wound healing and tissue regeneration in humans.

MEASUREMENTS AND OBSERVATIONS

Visual observations of shielded and unshielded specimens
Microscopic observations of shielded and unshielded animal fragments
Gross body activities, orientation, and reproductive behavior (cell division)
Organ histology
Radiation dosage

DESIRED MISSION DURATION

45 to 90 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Planaria species (dugesia) -- approximately 100
Aquaria
Radiation shielding
Radiation dosimeters
Freezer
Microscopes (compound and dissecting)
Timer
Camera (cine)
Histology kit
Microtome
Micromanipulators
Dissecting kit
Organism centrifuge (small)

SPECIAL REQUIREMENTS/REMARKS

A decline in capacity for tissue repair is also one characteristics of the aging process. Some of the "light memory" learning transfer experiments could be performed in orbit.

PERSONNEL REQUIRED

1 technician

REFERENCES

AIBS Annual Progress Report. Bioscience Research during Manned Earth-Orbiting Missions, Part Two. 24 October 1966.

LIFE SUPPORT AND PROTECTIVE SYSTEMS EXPERIMENT LIST

4-1 Advanced Integrated Life Support System I
4-2 Advanced Integrated Life Support System II
4-3 Integration of Radioisotope Power and EC/LS
4-4 Advanced Integrated Life Support Systems for Animals
4-5 Maintenance and Repair in Zero G
4-6 Advanced Two-Gas Atmosphere Supply and Control Subsystem
4-7 Advanced Fluid Management and Gaging Subsystem
4-8 Atmosphere Supply Methods and Components
4-9 Advanced Atmosphere Supply Subsystem
4-10 Electrolysis Methods and Components
4-11 Water Electrolysis Subsystem
4-12 Oxygen Recovery Methods and Components
4-13 Integrated Oxygen Recovery Subsystem
4-14 Carbon Dioxide Collection Methods and Components
4-15 Advanced Integrated Atmosphere Purification and Thermal Control Subsystems
4-16 Integrated Trace Contaminant Control and Monitoring Subsystem
4-17 Biological Control and Monitoring of Life Support Subsystems
4-18 Water Condenser-Separator Methods and Components
4-19 Advanced Cooling Methods and Components
4-20 Integrated Thermal Control System utilizing Waste Heat and Electrical Energy
4-21 Water Recovery Methods and Components
4-22 Regenerative Water Management Subsystem
4-23 Flight-Type Potability Monitoring System
4-24 Waste Management Methods and Components
4-25 Complete Waste Management Subsystem
4-26 Food Storage, Preparation, and Feeding Methods
4-27 Protective Clothing and Advanced Space Suit Assemblies
4-28 EVA Suit and Biopack
4-29 Cardiovascular Conditioning and Maintenance
4-30 Equipment and Procedures for Personal Hygiene
4-31 Fire Prevention and Sensing in Zero G or Reduced Gravity
4-32 Leak Detection
4-33 Flexible Airlock
4-34 Airlock Gas Conservation
4-35 Density Profiles of Liquid At and Near the Critical State
4-36 Capillary Studies
4-37 Kinetics and Dynamics of Gas Bubbles
4-38 Absorption of Gases by Liquids at Zero G
4-39 Gas-Free Liquid Maintenance
4-40 Static and Motion Tests of Interface Phenomena
4-41 Vapor Purge of Liquid Systems in Zero G

4-42 Transport of Solids by Gas Drag
4-43 Solid-to-Gas Heat Transfer in Cabin Air Heating
4-44 Gas-to-Solid Heat Transfer in Cabin Air Cooling
4-45 Cabin Air Distribution and Control
4-46 Effectiveness of Thermal Insulation and Surface Coatings
4-47 Convective Heat Transfer at Zero-G
4-48 Measurement of Solar Absorptivity and Thermal Emissivity of Various Materials by Spectrometry
4-49 Pool Boiling in Long-Term Zero G
4-50 Effect of Wall Temperature, Ventilation Rate, cabin Pressure, Gas Composition, and Crew Clothing on Comfort Level
4-51 Condensing Heat Transfer and Condensation Rate in Heat Exchangers
4-52 Transport of Liquids by Gas Drag
4-53 Water Recovery System Pretreatment Mixing
4-54 Composition Mixing and Heat Transfer
4-55 Solids and Fluids Combustion
4-56 Retention Techniques for Liquids and Solids during Equipment Servicing, Repair, and Maintenance
4-57 Manual Transport of Solids
4-58 Spillage Recovery and/or Cleanup

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-1

Advanced Integrated Life Support System I

EXPERIMENT CATEGORY

Advanced Integrated EC/LS--Life Support

OBJECTIVE AND SIGNIFICANCE

To flight verify an advanced integrated baseline life support system for post-Apollo missions.

MEASUREMENTS AND OBSERVATIONS

- Flow rate
- Pressure
- Temperature
- Contaminant level
- Water conductivity
- Humidity
- Power level
- Debris generation
- Gas composition
- Performance
- Visual observation
- Time
- Food- and water-use rate
- Waste-generation rate
- Water-generation rate
- Reliability and maintain ability
- Metabolic rate
- Use rate
- Leakage
- Biomedical data
- Ionized radiation level

EXPERIMENT DURATION

Life of space station and/or equipment.

SUBJECTS, MATERIALS, AND EQUIPMENT

- Test Specimens as follows:
  - Atmosphere supply and Pressurization
  - Atmosphere purification and control
  - Thermal control
  - Waste and water management
  - Food management
- Chemical laboratory
- Microbial laboratory
- Flow Meter
- Pressure sensor
- Dew-point meter
- Watt meter
- Gas chromatograph/ mass spectrometer
- Infrared spectrophotometer
- Leak detector
- Zero-g scale
- Timer
- Cine/still cameras
- Metabolic measuring device
- Work bench and tools
- Dosimeter
- Humidity sensor
- Baseline EC/LS Humidity sensor

SPECIAL REQUIREMENTS/REMARKS

The experiment selected must have been proven operational in a simulator. The experiment will not include 0_2 and food recovery but will include water recovery.

PERSONNEL REQUIRED

All on-board crew members

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

NASA Experiment Descriptions for Extended Apollo Earth Orbit Flights, 15 March 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-2

Advanced Integrated Life Support System II

EXPERIMENT CATEGORY

Advanced Integrated EC/LS--Life Support

OBJECTIVE AND SIGNIFICANCE

To flight verify an integrated life support system that is more advanced than the baseline system qualified in Experiment 4-1.

MEASUREMENTS AND OBSERVATIONS

- Flow rate
- Pressure
- Temperature
- Contaminant level
- Humidity
- Power level
- Debris generation
- Gas composition
- Performance
- Time
- Waste-generation rate
- Water-generation rate
- Reliability and maintainability
- Water conductivity
- Metabolic rate
- Use rate (of all materials)
- Leakage
- Biomedical data
- Ionized radiation level
- pH and COD

EXPERIMENT DURATION

Life of space station and/or equipment.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test Specimens as follows:
- Atmosphere supply and pressurization
- Atmosphere purification and control
- Thermal control
- Waste and water management
- Food management

- Baseline EC/LS
- Flow meter
- Pressure sensor
- Temperature sensor
- Dew-point meter
- Watt meter
- Gas chromatograph/ mass spectrometer
- Infrared spectrophotometer

- Emergency backup EC/LS
- Leak detector
- Zero-g scale
- Timer
- Cine/still cameras
- Metabolic measuring device
- Work bench and tools
- Dosimeter
- Humidity sensor
- Isotope heater

PERSONNEL REQUIRED

All on-board crew members

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

NASA Experiment Descriptions for Extended Apollo Earth Orbit Flights, 15 March 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-3

Integration of Radioisotope Power and EC/LS

EXPERIMENT CATEGORY

Integrated EC/LS and Power Systems--Life Support

OBJECTIVE AND SIGNIFICANCE

To flight verify a radioisotope power system integrated with a life support system that uses both the power system's waste heat and electrical energy.

MEASUREMENTS AND OBSERVATIONS

- Ionized radiation level
- Heat requirement
- Power level
- Temperature
- Pressure
- Flow rate
- Debris generation
- pH and COD
- Water conductivity
- Waste-generation rate
- Water-generation rate
- Biomedical data
- Time
- Humidity
- Gas composition
- Performance
- Reliability and maintainability
- Contaminant level
- Leakage
- Metabolic rate
- Use rate

EXPERIMENT DURATION

30 days, minimum.

SUBJECTS, MATERIALS, AND EQUIPMENT

- Test specimens
- Dosimeter
- Watt meter
- Flow meter
- Pressure sensor
- Temperature sensor
- Dew-point meter
- Gas chromatograph/ mass spectrometer
- Leak detector
- Baseline EC/LS
- Timer
- Cine/still cameras
- Zero-g scale
- Humidity sensor
- Isotope heater/power source
- Work bench and tools

SPECIAL REQUIREMENTS/REMARKS

Major EC/LS candidates that can use waste heat are molecular sieve/ silica gel CO_2 collectors, Bosch oxygen recovery, water sterilization and recovery units, water heaters, and toxin burners.

PERSONNEL REQUIRED

2 crew members

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

NASA Experiment Descriptions for Extended Apollo Earth Orbit Flights, 15 March 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-4

Advanced Integrated Life Support Systems for Animals

EXPERIMENT CATEGORY

Animal EC/LS--Life Support

OBJECTIVE AND SIGNIFICANCE

To determine the compatibility and workability of a totally integrated animal facility/manned facility.

MEASUREMENTS AND OBSERVATIONS

- Food- and water-use rate
- Pressure
- Temperature
- Waste-generation rate
- Power level
- Gas composition
- Biomedical data
- Visual observation
- Time
- Humidity
- Performance
- Microbiological contaminants
- Chemical contaminants
- Contaminant level
- Water-generation rate
- Urine/blood/biological samples
- Debris generation
- Reliability and maintainability
- Flow rate

EXPERIMENT DURATION

2 hours daily of crew time for 6 months.

SUBJECTS, MATERIALS, AND EQUIPMENT

- Test specimens
- Test food and water dispensers
- Pressure sensor
- Temperature sensor
- Flow meter
- Special sampling equipment
- Biomedical monitoring equipment
- Gas chromotograph/ mass spectrometer
- Biomedical monitoring equipment
- Animal housing
- Refrigerator
- Humidity sensor
- Timer
- Cine/still cameras
- Chemical laboratory
- Microbial laboratory
- Radiation laboratory
- Infrared spectrophotometer
- Zero-g scale
- Work bench and tools
- Watt meter
- Baseline EC/LS

SPECIAL REQUIREMENTS/REMARKS

This experiment requires long-duration testing with minimum monitoring by the crew. Life support systems for animals on board a manned spacecraft should consist of the EC/LS system for man, augmented with special equipment for contaminant control, waste control, and feeding. Hardware for collection and storage of blood, urine, and biological samples must be provided.

PERSONNEL REQUIRED

2 crew members

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

Study of an Animal Research Facility Using SIV-B for Manned Orbital Biotechnology Laboratory. Douglas Report No. DAC-58039, September 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-5

Maintenance and Repair in Zero G

EXPERIMENT CATEGORY

All EC/LS Systems

OBJECTIVE AND SIGNIFICANCE

To evaluate the tools, materials, special equipment, and techniques required for the on-board maintenance and repair of EC/LS equipment.

MEASUREMENTS AND OBSERVATIONS

Performance
Reliability and maintainability
Temperature
Leakage
Pressure
Power level
Time (to overhaul, replace)

EXPERIMENT DURATION

Mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Timer
Watt meter
Pressure sensor
Temperature sensor
Baseline EC/LS
Leak detector
Flow meter
Humidity sensor
Cine/still cameras
Dew-point meter
Space suit
Illumination device
Crew special restraints
Work bench and tools

SPECIAL REQUIREMENTS/REMARKS

All scheduled and unscheduled maintenance, repair times, and spare parts inventory must be recorded. Both intra- and extravehicular tasks would be investigated. Data obtained from this experiment will be used for the design of future life support systems, as well as tools, crew restraints, positioning, and locomotion devices.

PERSONNEL REQUIRED

All on-board crew members

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-6

Advanced Two-Gas Atmosphere Supply and Control Subsystem

EXPERIMENT CATEGORY

Atmosphere Supply and Pressurization--Two-Gas Control

OBJECTIVE AND SIGNIFICANCE

To flight verify a two-gas supply and control system.

MEASUREMENTS AND OBSERVATIONS

Pressure
Temperature
Gas composition
Flow rate
Power level
Time
Reliability and maintainability

EXPERIMENT DURATION

30 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Baseline EC/LS
Pressure sensor
Temperature sensor
Gas chromatograph
Chemical laboratory (calibration gas bottles and gases)
Flow meter
Humidity sensor
Timer
Watt meter
Work bench and tools

SPECIAL REQUIREMENTS/REMARKS

An advanced multigas mass spectrometer sensor and control have been tested and proven in a simulator. This device, as well as others, is available for flight test in conjunction with an atmosphere supply and storage system. This experiment can be completed as part of Experiments 4-1 and 4-2.

PERSONNEL REQUIRED

All on-board crew members

REFERENCES

IBM Experiment Program for Manned Earth Orbital Missions: Vol. I. IBM Report No. 65-928-63 (Contract No. NAS1-4667), August 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-7

Advanced Fluid Management and Gaging Subsystem

EXPERIMENT CATEGORY

Atmosphere Supply and Pressurization--Gaging

OBJECTIVE AND SIGNIFICANCE

To evaluate available methods for determining the amount of fluid remaining in the tanks as well as the location of the fluids.

MEASUREMENTS AND OBSERVATIONS

Pressure
Temperature
Boiloff rate
Delivery rate
Power level
Acceleration
Ionized radiation level
Time

EXPERIMENT DURATION

40 hours for each test specimen.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Pressure sensor
Temperature sensor
Flow meter
Radioisotope shielding
Cine camera
Accelerometer
Dosimeter
Timer
Work bench and tools
Watt meter

SPECIAL REQUIREMENTS/REMARKS

Conductivity grids and radioisotopes are representative proposed techniques.

PERSONNEL REQUIRED

2 crew members

REFERENCES

NASA Experiment Descriptions for Extended Apollo Earth Orbit Flights, 15 March 1965.

Douglas 211 Mission Experiment List. April 1966.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEST REF. NO. 4-8 (1 of 3)

Atmosphere Supply Methods and Components

EXPERIMENT CATEGORY

Atmosphere Supply and Pressurization--Nitrogen and Oxygen Supply

OBJECTIVE AND SIGNIFICANCE

To flight verify a subcritical storage system which will enable a weight and volume savings for many proposed Earth-orbital missions.

MEASUREMENTS AND OBSERVATIONS

Delivery rate (without heat input)
Delivery rate (with heat inputs)
Performance
Pressure
Temperature
Leakage
Power level
Time
Humidity
Heat requirement
Flow rate

EXPERIMENT DURATION

90 days, with data taken twice a day for 1-hour intervals.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Flow meter
Pressure sensor
Timer
Watt meter
Leak detector
Gaging unit
Baseline EC/LS
Temperature sensor

SPECIAL REQUIREMENTS/REMARKS

Recommended as a "piggy back" experiment where supercritical or gaseous atmospheric supply is used as the primary system until a subcritical unit has been flight qualified. This experiment can be conducted in conjunction with Experiments 4-1, 4-2, and 4-47.

PERSONNEL REQUIRED

2 crew members

REFERENCES

Experiment Program for One-Year Space Station Mission. Memorandum, George C. Marshall Space Flight Center, Huntsville, Alabama, 10 February 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-8 (2 of 3)

Atmosphere Supply Methods and Components (Chemical Storage and Supply)

EXPERIMENT CATEGORY

Atmosphere Supply--Nitrogen and Oxygen

OBJECTIVE AND SIGNIFICANCE

To obtain operational data in space on atmosphere supply subsystems that provide gas from superoxides, chlorate candles, hydrogen peroxide, nitrogen producing chemicals, etc.

MEASUREMENTS AND OBSERVATIONS

Temperature
Performance
Reliability and maintainability
Chemical contaminants
Contaminant level
Heat requirement
Pressure
Time
Humidity
Power requirement
Flow rate

EXPERIMENT DURATION

40 hours.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Flow meter
Pressure sensor
Gas chromatograph
Gas compressor
Accumulator
Baseline EC/LS
Timer
Humidity sensor
Chemical laboratory
Work bench and tools
Watt meter
Temperature sensor

SPECIAL REQUIREMENTS/REMARKS

Chemical storage of atmosphere gas supply may be used for application where long-term storage is a requirement. Applications include emergency breathing supply, space suit biopacks, and inflation of various devices.

PERSONNEL REQUIRED

2 crew members

REFERENCES

Analytical Methods for Space Vehicle Atmospheric Control Processes, Part II. Airesearch Manufacturing Company Report No. ASD-TDR-61-162 (Contract No. AF33[616]-8323).

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-8 (3 of 3)

Atmosphere Supply Methods and Components (Refrigeration/ Reliquefaction)

EXPERIMENT CATEGORY

Atmosphere Supply and Pressurization--Nitrogen and Oxygen Supply

OBJECTIVE AND SIGNIFICANCE

To evaluate a refrigeration of a reliquefaction subsystem.

MEASUREMENTS AND OBSERVATIONS

Pressure
Temperature
Flow rate (boiloff and recovery rate)
Heat requirement
Power level
Efficiency
Time
Heat transfer rate/heat balance

EXPERIMENT DURATION

30 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Flow meter
Pressure sensor
Temperature sensor
Special space radiator
Holding tanks
Cryogenic supply
Baseline EC/LS
Timer
Work bench and tools
Watt meter

SPECIAL REQUIREMENTS/REMARKS

The storage of cryogenic fluids for long missions using passive insulation techniques can involve excessive weight and volume penalties. An active refrigeration/reliquefaction system combined with thermal insulation may be necessary to conserve boiloff and minimize vehicle penalty. This experiment could be used to evaluate the performance for boiloff recovery systems for Interplanetary vehicle systems.

PERSONNEL REQUIRED

2 crew members

REFERENCES

Effects of the Reliquefaction System on the Auxiliary Power System Requirements for Interplanetary Missions. Douglas Paper No. DP-3003, 30 November 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-9

Advanced Atmosphere Supply Subsystem

EXPERIMENT CATEGORY

Atmosphere Supply and Pressurization--Nitrogen and Oxygen Supply

OBJECTIVE AND SIGNIFICANCE

To flight verify the advanced atmosphere supply subsystem that was deemed the best in Experiment 4-8.

MEASUREMENTS AND OBSERVATIONS

Reliability and maintainability
Performance
Flow rate
Pressure
Temperature
Power level
Leakage
Time

EXPERIMENT DURATION

30 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens (atmosphere supply, pressurization, and control subsystem)
Flow meter
Pressure sensor
Temperature sensor
Timer
Watt meter
Work bench and tools
Gas chromatograph
Baseline EC/LS

SPECIAL REQUIREMENTS/REMARKS

It appears that subcritical cryogenic storage is the first major candidate for test. Electrolysis units for O_2 regeneration from Experiment 4-11 are other candidates. The test should include sensors, controls, storage, delivery, and gaging equipment. This experiment could be conducted with Experiment 4-1.

PERSONNEL REQUIRED

1 crew member

REFERENCES

Experiment Program for One-Year Space Station Mission. Memorandum, George C. Marshall Space Flight Center, Huntsville, Alabama, 10 February 1967.

Engineering Criteria for Spacecraft Cabin Atmosphere Selection. Douglas Report No. DAC-59169 (Contract No. NAS2-1371), November 1966.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-10

Electrolysis Methods and Components

EXPERIMENT CATEGORY

Atmosphere Supply and Pressurization--Oxygen Supply

OBJECTIVE AND SIGNIFICANCE

To evaluate electrolysis subsystems that ground tests have proved to be operational.

MEASUREMENTS AND OBSERVATIONS

Power level
Flow rate (O_2 and H_2 generation and water usage)
Pressure
Temperature
Leakage
Reliability and maintainability
Time
Gas composition
Performance
Chemical contaminants
Contaminant level

EXPERIMENT DURATION

90 days continuous operation, with intermittent shut-down and start-up transients imposed.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens (Electrolysis Cells)
Flow meter
Pressure sensor
Gas chromatograph
Watt meter
Timer
Leak detector
Baseline EC/LS
Work bench and tools
Temperature sensor

SPECIAL REQUIREMENTS/REMARKS

The use of water for O_2 supply or as part of a closed-cycle oxygen recovery system can apply to future vehicles. A major problem in the use of electrolysis involves operation in zero g. Many concepts have been proposed, such as a rotating cell, ion exchange membrane, and KOH liquid matrix unit. This experiment should be conducted with Experiment 4-1

PERSONNEL REQUIRED

1 crew member

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

NASA Experiment Descriptions for Extended Apollo Earth Orbit Flights, 15 March 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-11

Water Electrolysis Subsystem

EXPERIMENT CATEGORY

Atmosphere Supply and Pressurization--Oxygen Supply

OBJECTIVE AND SIGNIFICANCE

To flight verify the electrolysis atmospheric supply and control system that was deemed the best in Experiment 4-10.

MEASUREMENTS AND OBSERVATIONS

Flow rate (O_2 and H_2 generation and water usage)
Power level
Gas composition
Leakage
Reliability and maintainability
Temperature
Pressure
Performance

EXPERIMENT DURATION

90-day mission, continuous operation, with the exception of shut-down and start-up performance evaluation.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Flow meter
Pressure sensor
Watt meter
Timer
Baseline EC/LS
Work bench and tools
Temperature sensor

SPECIAL REQUIREMENTS/REMARKS

This experiment can be conducted in place of Experiment 4-10, depending on hardware status at the time of experiment. Upon completion of Experiment 4-11 as a "piggy back" experiment an electrolysis unit should be used as the primary atmospheric supply for Experiment 4-2.

PERSONNEL REQUIRED

All on-board crew members

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

NASA Experiment Descriptions for Extended Apollo Earth Orbit Flights, 15 March 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-12

Oxygen Recovery Methods and Components

EXPERIMENT CATEGORY

Atmosphere Supply and Pressurization -- Oxygen Recovery

OBJECTIVE AND SIGNIFICANCE

To evaluate oxygen recovery devices.

MEASUREMENTS AND OBSERVATIONS

Temperature
Pressure
Gas composition
Power level
Flow rate
Time
Contaminant level
Chemical contaminants

EXPERIMENT DURATION

90 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Flow meter
Pressure
Baseline EC/LS sensor
Gas chromatograph
Holding tanks
Pumps, fans, and blowers
Humidity sensor
Timer
Chemical laboratory
Work bench and tools
Watt meter
Temperature sensor

SPECIAL REQUIREMENTS/REMARKS

Various methods are used to recover O_2 from CO_2, with the Sabatier and Bosch hydrogenation reactions being the most common for the production of water. The water can be electrolyzed to produce oxygen and hydrogen. The Sabatier process has proven successful in manned space cabin integrated EC/LS tests and should be the first unit flight qualified. Other O_2 recovery devices should be flight qualified as "piggy back" experiments when they have been proven operational in ground based testing. Experiment 4-1 would be used as the baseline EC/LS system during this particular test.

PERSONNEL REQUIRED

2 crew members

REFERENCES

NASA Experiment Descriptions for Extended Apollo Earth Orbit Flights, 15 March 1965.

Descriptive Titles of Experiments Selected by Langley Research Center. 15 November 1963.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-13

Integrated Oxygen Recovery Subsystem

EXPERIMENT CATEGORY

Atmosphere Supply and Repressurization -- Oxygen Recovery

OBJECTIVE AND SIGNIFICANCE

To flight verify, as an integrated system, the electrolysis and oxygen reactors and other components that were successfully flight tested in Experiments 4-10, 4-11, and 4-12.

MEASUREMENTS AND OBSERVATIONS

Flow rate
Pressure
Temperature
Gas composition
Efficiency
Water generation rate
Humidity
Power level
Reliability and maintainability
Heat requirement
Condensation rate
Performance
Chemical contaminants
Delivery rate

EXPERIMENT DURATION

90 days, continuous, except when start-up and shut-down experiments are conducted.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Flow meter
Pressure sensor
Accelerometers
Gas chromatograph
Infrared spectrophotometer
Baseline EC/LS
Humidity sensor
Chemical laboratory
Temperature sensor
Watt meter

SPECIAL REQUIREMENTS/REMARKS

The advanced integrated EC/LS system of Experiment 4-1 should be used as the baseline system. The first-generation O_2 recovery system that is flight qualified will become part of the Experiment 4-2 baseline for the testing and qualifying of more advanced units.

PERSONNEL REQUIRED

2 crew members

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

NASA Experiment Descriptions for Extended Apollo Earth Orbit Flights. 15 March 1965.

Descriptive Titles of Experiments Selected by Langley Research Center. 15 November 1963.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-14

Carbon Dioxide Collection Methods and Components

EXPERIMENT CATEGORY

Atmosphere Purification and Control -- Carbon Dioxide Control

OBJECTIVE AND SIGNIFICANCE

To flight verify advanced carbon dioxide removal subsystems.

MEASUREMENTS AND OBSERVATIONS

Flow rate
Efficiency
Pressure
Temperature
Power level
CO_2 removal rate
Time
Leakage
Gas composition
Performance
Heat requirement

EXPERIMENT DURATION

Qualification test data taken 15 min. twice daily for 90 days; reliability data for the life of equipment

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Flow meter
Pressure sensor
Gas chromatograph
Timer
Baseline EC/LS
Work bench and tools
Humidity sensor
Watt meter
Temperature sensor

SPECIAL REQUIREMENTS/REMARKS

Regenerative molecular sieves, carbonation cells, and other advanced CO_2 removal methods that permit vehicle penalty savings must be flight qualified. Currently, only the regenerative molecular sieve system has had sufficient development to be ready for flight qualification. Other advanced techniques look promising and will become available for qualification once they have been proven in ground-based tests.

PERSONNEL REQUIRED

2 crew members

REFERENCES

Analytical Methods for Space Vehicle Atmospheric Control Processes, Part II. Airesearch Manufacturing Company Report No. ASD-TDR-61-162 (Contract No. AF33 616 -8323).

Life Support Systems for Space Flight of Extended Time Periods. General Dynamics Report No. 64-26203 (Contract No. NAS9-2934).

A. D. Babinsky, et al. Carbon Dioxide Concentration System. NASA Report No. CR-72086. 30 July 1966.

T. C. Secord and M. S. Bonura. Life Support Data from Sixty-two Days of Testing in a Space Cabin Simulator. Douglas Paper No. DC-3397, October 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-15

Advanced Integrated Atmosphere Purification and Thermal Control Subsystems

EXPERIMENT CATEGORY

Atmosphere Purification and Control -- Carbon Dioxide Control

OBJECTIVE AND SIGNIFICANCE

To test and flight verify advanced life support subsystems regenerated with waste heat.

MEASUREMENTS AND OBSERVATIONS

Gas composition
Temperature
Pressure
Flow rate
Power level
Humidity
Time
Heat transfer rate/heat balance

EXPERIMENT DURATION

1 hour of crew time, twice daily, for 30 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Flow meter
Dew-point meter
Pressure sensor
Temperature sensor
CO_2 sensor
Watt meter
Baseline EC/LS
Gas chromatograph
Holding tanks
Timer
Humidity sensor
Pumps, fans and blowers

SPECIAL REQUIREMENTS/REMARKS

A molecular sieve CO_2 removal system cyclically uses thermal energy and vacuum to regenerate the sieve beds and to help transfer, with the assistance of a pump, the CO_2 in the sieves to the O_2 recovery system. Additionally, the silica gel beds are regenerated by the heat from the thermal control system. The beds are also cooled after regeneration by the thermal control system.

Experiment can be conducted with Experiment 4-1 or as part of Experiment 4-13.

PERSONNEL REQUIRED

2 crew members

REFERENCES

Final Technical Report Study of Zero Gravity Capabilities of Life Support System Components and Processes. Convair Division of General Dynamics Report No. GDC-DBD67-004, February 1968.

Space Marketing Intelligence-National Multipurpose Space Station (NMSS) Experimental Listing. Published by Space Station Study Office, National Aeronautics and Space Administration Manned Spacecraft Center, Houston, Texas, 17 December 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-16

Integrated Trace Contaminant Control and Monitoring Subsystem

EXPERIMENT CATEGORY

Atmosphere Purification and Control -- Trace Contaminant Control

OBJECTIVE AND SIGNIFICANCE

To flight verify a catalytic burner in conjunction with particulate filters and chemisorbent beds for trace contaminant removal and control, and an on-board monitoring and gas analysis device.

MEASUREMENTS AND OBSERVATIONS

Temperature
Pressure
Efficiency
Flow rate
Gas composition
Humidity
Time
Leakage
Power level
Performance
Reliability and maintainability
Chemical contaminants

EXPERIMENT DURATION

30 min. twice daily for 90 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Infrared spectrophotometer
Gas chromatograph/mass spectrometer
Chemical laboratory (calibration gas mixtures)
Baseline EC/LS
Temperature sensor
Pressure sensor
Flow meter
Humidity sensor
Timer
Watt meter
Leak detector

SPECIAL REQUIREMENTS/REMARKS

Experiment can be performed in conjunction with Experiments 4-1, 4-2, or 4-3

PERSONNEL REQUIRED

1 crew member

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-17

Biological Control and Monitoring of Life Support Subsystems

EXPERIMENT CATEGORY

Atmosphere Purification and Control--Microbial Control and Monitoring

OBJECTIVE AND SIFNIFICANCE

To evaluate optical measurement, resistance measurement, viable sampling by membrane filtration, and the Coulter Counter monitoring technique.

MEASUREMENTS AND OBSERVATIONS

Microbiological contaminants
Chemical contaminants
Effectiveness
Temperature
Pressure
Humidity
Leakage
Time
Power level
Flow rate

EXPERIMENT DURATION

Mission duration (as required).

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Microbiological laboratory
Chemical laboratory
Still camera
Gas chromatograph
Baseline EC/LS
Pressure sensor
Temperature sensor
Humidity sensor
Flow meter
Leak detector
Timer
Watt meter
Pumps, fans, and blowers

SPECIAL REQUIREMENTS/REMARKS

Microbial control chemical control and monitoring equipment and methods must be evaluated in zero. Experiment can be performed in conjunction with Experiments 4-1, 4-2, 4-3 4-4, 4-22, 4-23, and 4-25.

PERSONNEL REQUIRED

1 technician

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

Descriptive Titles of Experiments Selected by Langley Research Center. 15 November 1963.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-18

Water Condenser-Separator Methods and Components

EXPERIMENT CATEGORY

Thermal Control--Humidity Control

OBJECTIVE AND SIGNIFICANCE

To test and evaluate the most promising advanced water condenser-separator systems.

MEASUREMENTS AND OBSERVATIONS

Power level
Condensation rate
Heat balance
Flow rate
Temperature
Pressure
Water removal efficiency
Humidity
Time
Water conductivity

EXPERIMENT DURATION

24 hours for each test specimen; crew time is 30 min. every 8 hours.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Cine camera
Flow meter
Pressure sensor
Humidity sensor
Watt meter
Liquid pump
Baseline EC/LS
Timer
Temperature sensor

SPECIAL REQUIREMENTS/REMARKS

Experiments 4-51 and 4-52 can be performed as part of this experiment.

PERSONNEL REQUIRED

2 crew members

REFERENCES

Apollo Systems Earth Orbital Mission Definition Document. National Aeronautics and Space Administration Headquarters, Washington, D. C., January 1965.

R. S. Osborne, R. W. Johnson, and W. C. Thornton. Experiments for an Engineering Technology Satellite. National Aeronautics and Space Administration Langley Research Center, Virginia, 23 April 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-19

Advanced Cooling Methods and Components

EXPERIMENT CATEGORY

Thermal Control--Process Cooling

OBJECTIVE AND SIGNIFICANCE

To evaluate advanced cooling methods.

MEASUREMENTS AND OBSERVATIONS

Flow rate
Pressure
Temperature
Power level
Efficiency
Humidity
Reliability and maintainability
Performance
Heat transfer rate/heat balance

EXPERIMENT DURATION

90 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Flow meter
Pressure sensor
Temperature sensor
Watt meter
Baseline EC/LS
Humidity sensor
Pumps, fans, and blowers

SPECIAL REQUIREMENTS/REMARKS

One advanced radiator configuration that is currently a potential test candidate is a heat pipe. Absorption and vapor cycle heat pumps are other typical experiment candidates.

PERSONNEL REQUIRED

2 crew members

REFERENCES

R. S. Osborne, R. W. Johnson, and W. C. Thornton. Experiments for an Engineering Technology Satellite. National Aeronautics and Space Administration Langley Research Center, Virginia, 23 April 1965.

Temperature Control Systems for Space Vehicles: Parts I and II. North American Aviation, Inc. Report No. ASD-TDR-62-493, 1962-63.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-20

Integrated Thermal Control System Utilizing Waste Heat and Electrical Energy

EXPERIMENT CATEGORY

Thermal Control--Process Heating

OBJECTIVE AND SIGNIFICANCE

To compare the effectiveness of life support systems using electrical energy, waste heat, isotope energy, and the combination of these sources for process heating.

MEASUREMENTS AND OBSERVATIONS

- Efficiency
- Flow rate
- Pressure
- Temperature
- Power level
- Ionized radiation level
- Performance
- Heat requirement
- Reliability and maintainability
- Heat transfer rate/heat balance

EXPERIMENT DURATION

30 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

- Test specimens
- Flow meter
- Pressure sensor
- Temperature sensor
- Watt meter
- Baseline EC/LS
- Isotope heater
- Dosimeter
- Work bench and tools
- Biomedical monitoring equipment
- Radiation laboratory
- Radioisotope shielding

SPECIAL REQUIREMENTS/REMARKS

Experiment can be conducted in conjunction with or as part of Experiments 4-1, 4-2, 4-3, 4-4, 4-13, 4-14, 4-15, 4-22, and 4-25.

PERSONNEL REQUIRED

1 crew member

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

Thermal Integration of Electrical Power and Life Support Systems for Manned Spacecraft. General Electric Company. NASA Report No. CR-316 (Contract No. NAS3-2799), November 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-21

Water Recovery Methods and Components

EXPERIMENT CATEGORY

Water Management--Potable Water and Wash Water

OBJECTIVE AND SIGNIFICANCE

To compare the performance of the most promising concepts which have been proven in the manned space cabin simulator or other tests.

MEASUREMENTS AND OBSERVATIONS

pH and COD
Microbiological contaminants
Chemical contaminants
Power level
Pressure
Temperature
Flow rate
Reliability and maintainability
Time
Dew point
Performance
Water conductivity
Water-generation rate

EXPERIMENT DURATION

8 hours daily of crew time for 30 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Chemical laboratory
Microbia laboratory
Flow meter
Pressure sensor
Leak detector
Baseline EC/LS
Timer
Dew-point meter
Watt meter
Temperature sensor
Work bench and tools

SPECIAL REQUIREMENTS/REMARKS

Recovery of potable water from urine, humidity, or wash water can be accomplished by many processes such as air evaporation, vapor compression, electrodialysis, and reverse osmosis. Experiment can be conducted in conjunction with Experiments 4-1, 4-2, 4-17, 4-22, and 4-23.

PERSONNEL REQUIRED

2 crew members

REFERENCES

Space Marketing Intelligence-National Multipurpose Space Station (NMSS) Experimental Listing. Published by Space Station Study Office, National Aeronautics and Space Administration, Manned Spacecraft Center, Houston, Texas, 17 December 1964.

Mars Landing and Reconnaissance Mission Environmental Control and Life Support System Study, Vol. 3, System Studies (Contract No. NAS9-1701). 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-22

Regenerative Water Management Subsystem

EXPERIMENT CATEGORY

Water Management--Potable Water and Wash Water

OBJECTIVE AND SIGNIFICANCE

To flight verify an integrated regenerative water management subsystem which has been proven in the manned ground space cabin.

MEASUREMENTS AND OBSERVATIONS

pH and COD
Microbiological contaminants
Chemical contaminants
Power level
Pressure
Temperature
Reliability and maintainability
Time
Performance
Water conductivity
Water-generation rate
Flow rate

EXPERIMENT DURATION

Life of equipment.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Chemical laboratory
Microbia laboratory
Flow meters
Pressure sensor
Leak detector
Baseline EC/LS
Still camera
Timer
Watt meter
Temperature sensor

SPECIAL REQUIREMENTS/REMARKS

Long-duration missions will require recovery of potable water from humidity, urine, and wash water. Experiment can be performed in conjunction with Experiments 4-1, 4-2, 4-3, 4-17, and 4-23.

PERSONNEL REQUIRED

All on-board crew members

REFERENCES

Space Marketing Intelligence-National Multipurpose Space Station (NMSS) Experimental Listing. Published by Space Station Study Office, National Aeronautics and Space Administration, Manned Spacecraft Center, Houston, Texas, 17 December 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-23

Flight-Type Potability Monitoring System

EXPERIMENT CATEGORY

Water Management--Potability Verification

OBJECTIVE AND SIGNIFICANCE

To flight test a potability monitoring system.

MEASUREMENTS AND OBSERVATIONS

pH and COD
Microbiological contaminants
Power level
Pressure
Temperature
Flow rate
Time
Reliability and maintainability
Chemical contaminants
Dew point
Water conductivity
Water-generation rate

EXPERIMENT DURATION

8 hours daily of crew time for 30 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Chemical laboratory
Microbia laboratory
Flow meter
Pressure sensor
Baseline EC/LS
Timer
Dew-point meter
Watt meter
Temperature sensor

SPECIAL REQUIREMENTS/REMARKS

Regenerative water-recovery units recovering potable water from humidity, urine, and wash water will require constant monitoring for potability. Experiment can be conducted in conjunction with Experiments 4-1 and 4-22.

PERSONNEL REQUIRED

1 crew member

REFERENCES

MDAC originated.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-24

Waste Management Methods and Components

EXPERIMENT CATEGORY

Waste Management--Feces and Urine Collection

OBJECTIVE AND SIGNIFICANCE

To evaluate waste management methods and components.

MEASUREMENTS AND OBSERVATIONS

Heat requirement	Temperature
Vacuum requirement	Pressure
Time	Flow rate
Power level	Performance
Chemical contaminants	Reliability and maintainability
Efficiency	Microbiological contaminants

EXPERIMENT DURATION

30 days for each major unit; crew time is 1 hour twice daily.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens	Cine camera
Pressure sensor	Temperature sensor
Chemical laboratory	Flow meter
Microbial laboratory	Watt meter
Baseline EC/LS	Timer

SPECIAL REQUIREMENTS/REMARKS

Urine collection devices, such as gas entrainment and centrifugation, diaphragm units, and sleeve attachments, must be evaluated in zero g. Waste disposal and processing techniques must be compared. The most favorable devices can be tested as an integrated system and qualified in Experiment 4-25. Experiment can be performed in conjunction with Experiments 4-1 or 4-2.

PERSONNEL REQUIRED

All on-board crew members.

REFERENCES

Life Support Systems for Space Flight of Extended Time Periods. General Dynamics Report No. 64-26203 (Contract No. NAS9-2934).

N. Belasco and D. Perry. Waste Management and Personal Hygiene for Extended Spacecraft Missions. National Aeronautics and Space Administration Manned Spacecraft Center, Houston, Texas, April 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-25

Complete Waste Management Subsystem

EXPERIMENT CATEGORY

Waste Management--Feces and Urine Collection

OBJECTIVE AND SIGNIFICANCE

To flight verify a urine and feces collector, vacuum/thermal dehydration unit, or a chemical treatment device and other waste management equipment.

MEASUREMENTS AND OBSERVATIONS

Heat requirement
Vacuum requirement
Time
Power level
Chemical contaminants
Efficiency
Temperature
Performance
Pressure
Flow rate
Debris generation
Reliability and maintainability
Microbiological contaminants

EXPERIMENT DURATION

Crew and technicians use 1 hour each, twice daily, for 30 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Pressure sensor
Chemical laboratory
Microbial laboratory
Baseline EC/LS
Cine camera
Flow meter
Watt meter
Timer
Temperature sensor

SPECIAL REQUIREMENTS/REMARKS

The processing and disposal of human waste and debris in zero g imposes special requirements on the waste management subsystem. Experiment can be performed in conjunction with Experiments 4-1 and 4-2. Equipment listed in Experiment 4-24 are candidates for the test.

PERSONNEL REQUIRED

All on-board crew members.

REFERENCES

Space Marketing Intelligence-National Multipurpose Space Station (NMSS) Experimental Listing. Published by Space Station Study Office, National Aeronautics and Space Administration, Manned Spacecraft Center, Houston, Texas, 17 December 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-26

Food Storage, Preparation, and Feeding Methods

EXPERIMENT CATEGORY

Food Management--Food Supply

OBJECTIVE AND SIGNIFICANCE

To evaluate food, feeding methods, storage, preparation techniques, and waste disposal methods that have been proven in ground-based space cabin simulator tests.

MEASUREMENTS AND OBSERVATIONS

Food palatability	Humidity	Use rate
Diet	Temperature	Food and water use rate
Debris generation	Pressure	Waste-generation rate
Power level	Metabolic rate	Food storage and preparation

EXPERIMENT DURATION

30 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens (food preparation equipment)	Temperature sensor	Chemical laboratory
Baseline EC/LS	Pressure sensor	Microbial laboratory
Zero-g scale	Humidity sensor	Ergometer
Watt meter	Biomedical monitoring equipment	Metabolic measuring device

SPECIAL REQUIREMENTS/REMARKS

Food management for long-duration flight involves food storage, preparation, feeding devices, and debris disposal. Freeze dried or possibly frozen food cooked in small microwave ovens may be used. Other possibilities involve algae or synthesis of sugars for food on prolonged space missions. Human engineering and medical experiments can be conducted in conjunction with this test.

PERSONNEL REQUIRED

All on-board crew members

REFERENCES

IBM Experiment Program for Manned Earth Orbital Missions: Vol. I. IBM Report No. 65-928-63 (Contract No. NAS1-4667), August 1965.

Space Marketing Intelligence-National Multipurpose Space Station (NMSS) Experimental Listing. Published by Space Station Study Office, National Aeronautics and Space Administration, Manned Spacecraft Center, Houston, Texas, 17 December 1964.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-27

Protective Clothing and Advanced Space Suit Assemblies

EXPERIMENT CATEGORY

Crew Protection--Clothing/Space Suit

OBJECTIVE AND SIGNIFICANCE

To evaluate advanced space suits and other protective equipment.

MEASUREMENTS AND OBSERVATIONS

Comfort criteria	Power level	Performance
Mobility	Flow rate	Ionized radiation level
Pressure	Time	Leakage
Temperature	Humidity	Biomedical monitoring
Gas composition		

EXPERIMENT DURATION

1 hour for each of 20 tests.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimen	Flow meter	Cine camera
Pressure sensor	Humidity sensor	Work bench and tools
Leak Detector	Gas chromatograph	Ignition device
Baseline EC/LS	Biomedical monitoring equipment	Watt meter
Temperature sensor		

SPECIAL REQUIREMENTS/REMARKS

Space suits and cooled undergarments, as well as constant wear garments, will be required for EVA, IVA, and emergency operations. Experiment can be done in conjunction with Experiment 4-28 and behavioral experiments.

PERSONNEL REQUIRED

2 crew members

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

NASA Experiment Descriptions for Extended Apollo Earth Orbit Flights, 15 March 1965.

IBM Experiment Program for Manned Earth Orbital Missions: Vol. I. IBM Report No. 65-928-63 (Contract No. NAS1-4667), August 1965.

Experiment Program for One-Year Space Station Mission. Memorandum, George C. Marshall Space Flight Center, Huntsville, Alabama, 10 February 1967.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-28

EVA Suit and Biopack

EXPERIMENT CATEGORY

Crew Protection--Backpack and Space Suit

OBJECTIVE AND SIGNIFICANCE

To evaluate a crewman clothed in the spacesuit, and to evaluate the effectiveness and durability of the spacesuit and biopack through a complete spectrum of motion and environment.

MEASUREMENTS AND OBSERVATIONS

- Humidity
- Pressure
- Temperature
- Flow rate
- Mobility
- Gas composition
- Comfort criteria
- Power level
- Time
- Leakage
- Performance
- Contaminant level
- Metabolic rate
- Biomedical monitoring

EXPERIMENT DURATION

1 hour for each of 20 tests.

SUBJECTS, MATERIALS, AND EQUIPMENT

- Test specimens
- Pressure sensor
- CO_2 sensor
- Gas Chromatograph
- Baseline EC/LS
- Flow meter
- Cine camera
- Tethers/umbilicals
- Biomedical monitoring equipment
- Watt meter
- Leak detector
- Timer
- Humidity sensor
- Temperature sensor

SPECIAL REQUIREMENTS/REMARKS

Experiment can be done in conjunction with Experiment 4-27 and behavioral experiments.

PERSONNEL REQUIRED

2 crew members

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

Descriptive Titles of Experiments Selected by Langley Research Center. 15 November 1963.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-29

Cardiovascular Conditioning and Maintenance

EXPERIMENT CATEGORY

Crew Protection--Gravity Compensation

OBJECTIVE AND SIGNIFICANCE

To evaluate and compare various cardiovascular conditioning and maintenance devices.

MEASUREMENTS AND OBSERVATIONS

Temperature
Centrifugal force
Power level
Time
Metabolic rate
Biomedical monitoring
Acceleration

EXPERIMENT DURATION

20 min. daily for mission duration.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Biomedical monitoring equipment
Cine camera
Pressure sensor
Temperature sensor
Accelerometer
Humidity sensor
Timer
Metabolic measuring device
Cine/still cameras
Pumps, fans, and blowers
Watt meter

SPECIAL REQUIREMENTS/REMARKS

A physical conditioning program for the flight crew may be required on long space missions to prevent physiological deterioration of the crewmen in the absence of gravity. Such devices as an ergometer, pressure cuffs, a lower-body negative pressure boot, or a centrifuge could be useful to maintain and, in some instances, monitor physical condition. Experiment can be conducted in conjunction with medical and behavioral experiments. Centrifuge can also be used to mount a scale for weighing.

PERSONNEL REQUIRED

All on-board crew members

REFERENCES

NASA Experiment Descriptions for Extended Apollo Earth Orbit Flights, 15 March 1965.

Descriptive Titles of Experiments Selected by Langley Research Center. 15 November 1963.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-30

Equipment and Procedures for Personal Hygiene

EXPERIMENT CATEGORY

Crew Protection--Personal Hygiene

OBJECTIVE AND SIGNIFICANCE

To flight verify body bathing, dental hygiene, hair cutting, shaving, and other personal hygiene equipment.

MEASUREMENTS AND OBSERVATIONS

Visual observations
Flow rate
Equipment effectiveness
Pressure
Temperature
Power level
Performance

EXPERIMENT DURATION

40 hours.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Baseline EC/LS
Pressure sensor
Temperature sensor
Watt meter
Work bench and tools
Cine camera

SPECIAL REQUIREMENTS/REMARKS

Behavioral tests can also be conducted simultaneously with this experiment.

PERSONNEL REQUIRED

All on-board crew members

REFERENCES

IBM Experiment Program for Manned Earth Orbital Missions: Vol. I. IBM Report No. 65-928-63 (Contract No. NAS1-4667), August 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-31

Fire Prevention and Sensing in Zero-G or Reduced-Gravity

EXPERIMENT CATEGORY

Crew Protection--Fire Protection

OBJECTIVE AND SIGNIFICANCE

To evaluate and flight verify fire sensing, control, and extinguishing methods.

MEASUREMENTS AND OBSERVATIONS

Total energy
Temperature
Ignition time
Gas-generation rate
Gas composition
Burning rate
Humidity
Power level
Pressure
Time
Velocity/velocity profile

EXPERIMENT DURATION

4 hours for each experiment.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Cine camera
Temperature sensor
Pressure sensor
Fire detector
Fire-extinguishing agents
Gas chromatograph
Baseline EC/LS
Optical pyrometer
Timer
Chemical laboratory
Humidity sensor
Flow meter
Watt meter
Ignition device

SPECIAL REQUIREMENTS/REMARKS

This experiment may be performed in conjunction with or as part of Experiments 4-54 and 4-55.

PERSONNEL REQUIRED

2 crew members

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-32

Leak Detection

EXPERIMENT CATEGORY

Crew-Protection--Leakage

OBJECTIVE AND SIGNIFICANCE

To qualify leak detection devices.

MEASUREMENTS AND OBSERVATIONS

Flow rate
Temperature
Pressure
Humidity
Power level
Time
Leakage

EXPERIMENT DURATION

1 hour daily for 7 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Baseline EC/LS
Pressure sensor
Temperature sensor
Humidity sensor
Watt meter
Timer
Flow meter
Leak detector

SPECIAL REQUIREMENTS/REMARKS

The experiment can be conducted with Experiments 4-1 and 4-9. Leak location and repair methods can be evaluated as part of this experiment when they become available.

PERSONNEL REQUIRED

2 crew members

REFERENCES

Douglas 211 Mission Experiment List. April 1966.

Engineering Criteria for Spacecraft Cabin Atmosphere Selection. Douglas Report No. DAC-59169 (Contract No. NAS2-1371), November 1966.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-33

Flexible Airlock

EQUIPMENT CATEGORY

Crew Protection--Airlock

OBJECTIVE AND SIGNIFICANCE

To evaluate a flexible airlock.

MEASUREMENTS AND OBSERVATIONS

Power level
Pressure
Temperature
Time
Leakage

EXPERIMENT DURATION

4 hours.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Pressure sensor
Temperature sensor
Flow meter
Watt meter
Baseline EC/LS
Cine/still cameras
Tether/umbilicals
Timer
Leak detector
Special clothing/space suits
EC/LS back pack

SPECIAL REQUIREMENTS/REMARKS

Airlocks made of flexible material have been proposed to minimize weight and volume.

PERSONNEL REQUIRED

2 crew members

REFERENCES

MDAC originated.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-34

Airlock Gas Conservation

EXPERIMENT CATEGORY

Crew Protection--Airlock

OBJECTIVE AND SIGNIFICANCE

To evaluate airlock gas conservation equipment and methods for flight verification of an airlock gas conservation subsystem.

MEASUREMENTS AND OBSERVATIONS

Pressure
Temperature
Flow rate
Power level
Time
Leakage

EXPERIMENT DURATION

8-hour intervals for 2 weeks, for each type of gas conservation unit tested.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens (airlock, motor/pump combination, and controls)
Flow meter
Pressure sensor
Temperature sensor
Watt meter
Holding tanks (if the cabin is not used as a reservoir)
Space suits
Timer
Baseline EC/LS (atmospheric supply system)
Tether/umbilicals
Illumination device
Special clothing/space suits

SPECIAL REQUIREMENTS/REMARKS

The atmosphere used in the operation of an airlock can be recovered by a pumpdown system pumping the gas from the airlock into the cabin or into low pressure storage vessels. An airlock and vent system required for the experiment. The airlock gas can be pumped into the cabin or into a holding tank for reuse.

PERSONNEL REQUIRED

2 crew members

REFERENCES

Engineering Criteria for Spacecraft Cabin Atmosphere Selection. Douglas Report No. DAC-59169 (Contract No. NAS2-1371), November 1966.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-35

Density Profiles of Liquid At and Near the Critical State

EXPERIMENT CATEGORY

Atmosphere Supply--Cryogenic Fluids

OBJECTIVE AND SIGNIFICANCE

To validate Meyers' theory of condensation.

MEASUREMENTS AND OBSERVATIONS

Density
Pressure
Temperature
Time

EXPERIMENT DURATION

2-1/2 hours for each of 6 tests.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens	Temperature sensor
Cryogenic supply	Cine/still cameras
Chemical laboratory	Timer
Pressure sensor	Optical density sensor

SPECIAL REQUIREMENTS/REMARKS

The density profile of a column of near-critical-state liquid has been found to be much larger than that attributable to the static head. Sedimentation or condensation are possible explanations. Meyers theory involves condensation with the belief that the saturation line is a region which permits two phases to exist. Low-gravity tests are required to validate the theory. The resulting data would be useful in designing liquid-handling equipment, gauging, and expulsion devices.

PERSONNEL REQUIRED

1 crew member

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

NASA Experiment Descriptions for Extended Apollo Earth Orbit Flights. 15 March 1965.

Descriptive Titles of Experiments Selected by Langley Research Center. 15 November 1963.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-36

Capillary Studies

EXPERIMENT CATEGORY

Atmosphere Supply/Thermal Control/Water Management--Liquid Gas Separation

OBJECTIVE AND SIGNIFICANCE

To obtain a better understanding of the interactions of matter at solid/liquid/vapor interfaces.

MEASUREMENTS AND OBSERVATIONS

Time
Pressure
Temperature
Flow rate
Acceleration
Wetting angle
Surface tension
Viscosity

EXPERIMENT DURATION

30 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens (spiral and straight tube of different I. D., and flat plate sample surfaces)
Timer
Accelerometer
Test container with bladder
Baseline EC/LS (hot and cold fluid and pressure sources)
Cine/still cameras
Pressure sensor
Temperature sensor

SPECIAL REQUIREMENTS/REMARKS

The behavior of such interfaces is an important factor in the design of heat exchangers, gas separators, and many other life support hardware. Theory requires correction or verification to enable proper design.

PERSONNEL REQUIRED

1 crew member

REFERENCES

NASA Experiment Descriptions for Extended Apollo Earth Orbit Flights, 15 March 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-37

Kinetics and Dynamics of Gas Bubbles

EXPERIMENT CATEGORY

Atmosphere Supply/Thermal Control/Water Management Systems--Liquid Gas Behavior

OBJECTIVE AND SIGNIFICANCE

To obtain a better understanding of nucleated boiling and the kinetics of bubble growth and collapse under transient conditions free from convection in the liquid or bubble migration.

MEASUREMENTS AND OBSERVATIONS

Heat transfer rate/heat balance	Heat flux
Surface tension	Acceleration
Pressure	Time
Temperature	Density

EXPERIMENT DURATION

1 hour daily for 30 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens	Pressure controller
Cine camera	Timer
Illumination device	Accelerometer
Pressure sensor	Bubble chamber
Temperature sensor	

SPECIAL REQUIREMENTS/REMARKS

This type of basic information can be applied in the better design of life support components that involve heat transfer and liquid/gas separation. Bubble growth and collapse rate for both large (≥5 mm) and small (≤5 mm) bubbles, bubble surface oscillations, and oscillation modes induced both by external pressure pulses and bubble movement, and bubble migration rates under low vehicle accelerations ($<10^{-2}$ g).

PERSONNEL REQUIRED

1 crew member

REFERENCES

NASA Experiment Descriptions for Extended Apollo Earth Orbit Flights. 15 March 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-38

Absorption of Gases by Liquids at Zero-G

EXPERIMENT CATEGORY

Atmosphere Supply/Thermal Control/Water Management--

OBJECTIVE AND SIGNIFICANCE

To determine the amount of vital gases, carbon dioxide, oxygen, and contaminants that can be absorbed by fluids.

MEASUREMENTS AND OBSERVATIONS

Gas flow distribution
Absorption rate
Pressure
Temperature
Gas composition
Liquid composition
Time

EXPERIMENT DURATION

1 hour daily for 30 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens (filters and membranes)
Pyrex flask
Plastic squeeze container
Hand pump
Shadowgraph
Chemical laboratory (liquid analysis)
Pressure sensor
Timer
Heating element
Temperature sensor

SPECIAL REQUIREMENTS/REMARKS

The absorption rate and gas distribution within the liquid can also be investigated. This type of information furnishes a background for life support systems that use liquid suspension systems.

PERSONNEL REQUIRED

1 crew member

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

Descriptive Titles of Experiments Selected by Langley Research Center. 15 November 1963.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-39

Gas-Free Liquid Maintenance

EXPERIMENT CATEGORY

Atmosphere Supply/Thermal Control/Water Management--Liquid Gas Separation

OBJECTIVE AND SIGNIFICANCE

To test gas-free liquid maintenance devices applicable to thermal control, electrolysis, and other subsystems.

MEASUREMENTS AND OBSERVATIONS

Gas composition
Pressure
Temperature
Power level
Flow rate
Time
Effectiveness
Humidity
Liquid composition

EXPERIMENT DURATION

1 hour daily for 30 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens (semi-permeable membrane, porous plate, or other gas/liquid separators)
Mass spectrometer
Flow meter
Humidity sensor
Pressure sensor
Watt meter
Timer
Temperature sensor
Pyrex flask
Heating element

SPECIAL REQUIREMENTS/REMARKS

The maintenance of gas-free liquids in zero g may require specialized devices or gas separators.

PERSONNEL REQUIRED

1 crew member

REFERENCES

Final Technical Report Study of Zero Gravity Capabilities of Life Support System Components and Processes. Convair Division of General Dynamics Report No. GDC-DBD67-004, February 1968.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-40

Static and Motion Tests of Interface Phenomena

EXPERIMENT CATEGORY

Atmosphere Supply/Thermal Control/Water Management--Liquid Gas Separation

OBJECTIVE AND SIGNIFICANCE

To measure various interface phenomena in zero-g conditions.

MEASUREMENTS AND OBSERVATIONS

Surface tension
Wetting angle
Surface shapes
Damping
Motion characteristics
Temperature
Orientation
Pressure
Time
Density

EXPERIMENT DURATION

1 hour daily for 30 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Cine camera
Pyrex flask
Heating element
Orientation device
Pressure sensor
Timer
Dialectrophorese device
Shadowgraph

SPECIAL REQUIREMENTS/REMARKS

In a series of static tests, surface shapes of liquid-liquid, liquid-gas, liquid-vapor, and liquid-liquid-gas systems would be measured to determine intermolecular forces and forces resulting from surface tension and wetting. In addition, solid-liquid interfaces would be studied by means of models of baffles and pick-up tubes. Observations would also be made during period when the laboratory spacecraft is being accelerated during orbit keeping. The data from the experiment can be used to design such items as gaging and expulsion devices.

PERSONNEL REQUIRED

1 crew member

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

Descriptive Titles of Experiments Selected by Langley Research Center. 15 November 1963.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-41

Vapor Purge of Liquid Systems in Zero-G

EXPERIMENT CATEGORY

Atmosphere Supply/Thermal Control/Water Management/Waste Management--Solid and Liquid Retention

OBJECTIVE AND SIGNIFICANCE

To evaluate separating techniques of small quantities of noncondensable gases from spacecraft liquid systems.

MEASUREMENTS AND OBSERVATIONS

Water use
Vapor removal efficiency
Visual observation
Temperature
Pressure

EXPERIMENT DURATION

15 min. for each test; repeat 16 times.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens (fluid test rig and pump)
Baseline EC/LS (water supply and heat transport fluid supply)
Temperature sensor
Pressure sensor
Photo cell

SPECIAL REQUIREMENTS/REMARKS

Small quantities of noncondensable gases in liquid systems may contribute to corrosion, pump cavitation, heat-exchanger inefficiency, and other problems. Examples of such problem areas in spacecraft life support systems are air carry-over into urine, cabin air condensate, and wash water storage tanks. In addition, heat transfer loops should be purged periodically to remove dissolved gas that may be desorbed because of pressure or temperature changes.

PERSONNEL REQUIRED

1 crew member

REFERENCES

R. S. Osborne, R. W. Johnson, and W. C. Thornton. Experiments for an Engineering Technology Satellite. National Aeronautics and Space Administration Langley Research Center, Virginia, 23 April 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-42

Transport of Solids by Gas Drag

EXPERIMENT CATEGORY

Water and Waste Management--Solid Transport by Gas Drag

OBJECTIVE AND SIGNIFICANCE

To obtain data on devices that require solid transport and retention by gas drag.

MEASUREMENTS AND OBSERVATIONS

Velocity/velocity profile
Friction
Density
Efficiency

EXPERIMENT DURATION

40 nours.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Cine/still cameras
Reference background grid
Solid/gas separator
Pressure sensor
Temperature sensor
Friction-measuring equipment
Flow meter
Timer
Zero-g scale

SPECIAL REQUIREMENTS/REMARKS

Transport of solids by gas drag is used for such things as the removal and retention of carbon particles from the Bosch reaction in oxygen recovery, the removal of solid contaminants in the atmosphere, the transport of debris, and the direction control and retention of fecal matter in a commode. A range of solids of densities representative of those requiring transport must be used. A variation in flow velocity must be investigated for each particle type.

PERSONNEL REQUIRED

1 crew member

REFERENCES

MDAC originated.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-43

Solid-to-Gas Heat Transfer in Cabin Air Heating

EXPERIMENT CATEGORY

Thermal Control--Atmosphere Circulation

OBJECTIVE AND SIGNIFICANCE

To obtain zero-g heat-transfer effectiveness data between the atmosphere and solid surfaces at various forced-convection rates.

MEASUREMENTS AND OBSERVATIONS

- Temperature
- Surface temperature
- Gas velocities and flow rate
- Gas composition
- Pressure
- Humidity
- Time
- Power level
- Flow rate
- Heat transfer rate/ heat balance
- Velocity/velocity profile

EXPERIMENT DURATION

30 min. for each of 80 tests.

SUBJECTS, MATERIALS, AND EQUIPMENT

- Temperature sensor
- Pressure sensor
- Baseline EC/LS (heat source device and heat sink)
- Gas chromatograph
- Flow meter
- Velocity meter
- Timer
- Watt meter

SPECIAL REQUIREMENTS/REMARKS

Solid-to-gas heating in space is primarily dependent on condition and forced convection since free convection is dependent on gravity. Failure to provide adequate forced convection will cause increased temperature differentials between exposed surfaces and the atmosphere. Solid-to-gas heat transfer involves removing heat from pumps, waste processing, lights, fans, electronics, and similar components.
The data can be obtained as a part of an integrated EC/LS experiment.

PERSONNEL REQUIRED

1 crew member

REFERENCES

Final Technical Report Study of Zero Gravity Capabilities of Life Support System Components and Processes. Convair Division of General Dynamics Report No. GDC-DBD67-004, February 1968.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-44

Gas-to-Solid Heat Transfer in Cabin Air Cooling

EXPERIMENT CATEGORY

Thermal Control--Atmosphere Circulation

OBJECTIVE AND SIGNIFICANCE

To obtain zero-g heat transfer data for design purposes; and to verify proper operation of thermal control systems being used as the experiment.

MEASUREMENTS AND OBSERVATIONS

Pressure
Temperature
Flow rate
Gas velocity
Gas composition
Humidity
Heat exchanger effectiveness
Time
Heat transfer rate/heat balance

EXPERIMENT DURATION

30 min. for each of 80 tests.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens (heat exchanger and heat sink)
Pressure sensor
Flow meter
Velocity meter
Gas chromatograph
Timer
Baseline EC/LS
Humidity sensor
Temperature sensor

SPECIAL REQUIREMENTS/REMARKS

Gas-to-solid heat transfer is involved in absorbing heat from the atmosphere by heat exchangers or cold surfaces. This type of heat transfer is gravity dependent because of the lack of free convection. Gas-to-solid heat transfer involves atmosphere cooling and condensation. The data can be obtained as part of an integrated EC/LS experiment.

PERSONNEL REQUIRED

1 crew member

REFERENCES

Final Technical Report Study of Zero Gravity Capabilities of Life Support System Components and Processes. Convair Division of General Dynamics Report No. GDC-DBD67-004, February 1968.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-45

Cabin Air Distribution and Control

EXPERIMENT CATEGORY

Thermal Control--Atmosphere Circulation

OBJECTIVE AND SIGNIFICANCE

To determine the distribution and control of cabin gas and temperature in low gravity. Additionally, the removal and control of contaminants will be evaluated.

MEASUREMENTS AND OBSERVATIONS

Temperature
Flow rate
Humidity
Gas composition
Power level
Pressure
Velocity/velocity profile
Visual observation

EXPERIMENT DURATION

1 hour daily for 30 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Baseline EC/LS (thermal control unit)
Flow meter
Velocity meter
Humidity sensor
Dew-point meter
Gas chromatograph
Chemical laboratory (calibration gas)
Infrared spectrophotometer
Temperature sensor
Watt meter

SPECIAL REQUIREMENTS/REMARKS

Control of the spacecraft temperature is accomplished by maintaining a balance between heat input from various sources and heat absorbed in various heat exchangers or by low temperature walls. On-board thermal control system can be used with adapters for flow modulation.

PERSONNEL REQUIRED

1 crew member

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

NASA Experiment Descriptions for Extended Apollo-Earth Orbit Flights, 15 March 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-46

Effectiveness of Thermal Insulation and Surface Coatings

EXPERIMENT CATEGORY

Thermal Control--Heat Transfer

OBJECTIVE AND SIGNIFICANCE

To evaluate insulation types and configurations and the effect of surface coating.

MEASUREMENTS AND OBSERVATIONS

- Pressure
- Surface finish
- Reflective index
- Temperature
- Absorbtivity/emissivity
- Velocity/velocity profile
- Gas composition
- Heat transfer rate/heat balance

EXPERIMENT DURATION

Intermittent tests during life of spacecraft; measurements should be taken daily first month, then monthly for each test specimen; each test evaluation period is estimated at 8 hours.

SUBJECTS, MATERIALS, AND EQUIPMENT

- Test specimens (minimum of 120)
- Temperature sensor
- Pressure sensor
- Timer
- Integrating reflectometer
- Velocity meter
- Chemical laboratory (chemical analysis kit)
- Work bench and tools
- Dew-point meter
- Flow meter

SPECIAL REQUIREMENTS/REMARKS

The data are needed to provide more optimum thermal control design.

PERSONNEL REQUIRED

2 crew members

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

IBM Experiment Program for Manned Earth Orbital Missions: Vol. I. IBM Report No. 65-928-63 (Contract No. NAS1-4667), August 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-47

Convective Heat Transfer at Zero-G

EXPERIMENT CATEGORY

Thermal Control/Atmosphere Supply--Heat Transfer

OBJECTIVE AND SIGNIFICANCE

To determine the heat transfer coefficients in a low-g environment to supplement or to confirm existing information.

MEASUREMENTS AND OBSERVATIONS

- Pressure
- Temperature
- Amps
- Volts
- Acceleration
- Power level
- Time
- Velocity

EXPERIMENT DURATION

24 hours for each test.

SUBJECTS, MATERIALS, AND EQUIPMENT

- Test specimens (vent systems, containers and reservoir, test fluids, instrumented test chamber and heater, and motor and control mechanism)
- Oscillograph
- Volt meter
- Amp meter
- Cine/still cameras
- Zero-g scale
- Baseline EC/LS
- Shadowgraph
- Accelerometers
- Illumination device
- Watt meter
- Temperature sensor
- Pressure sensor
- Humidity sensor

SPECIAL REQUIREMENTS/REMARKS

One technique for supplying an atmosphere to a manned space vehicle is the stored atmosphere supply system; such a system utilizes liquid oxygen and liquid nitrogen. In the design of future spacecraft, it would be desirable to know the heat transfer characteristics of liquid containers in a low-g space environment. The information gained from this experiment could be used to determine boiloff rates and insulation requirements for the liquid containers. Although the experiment is intended for a life support system, the test results could be applied to other systems requiring a cryogenic supply.

PERSONNEL REQUIRED

2 crew members

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

IBM Experiment Program for Manned Earth Orbital Missions: Vol. I. IBM Report No. 65-928-63 (Contract No. NAS1-4667), August 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-48

Measurement of Solar Absorptivity and Thermal Emissivity of Various Materials by Spectrometry

EXPERIMENT CATEGORY

Thermal Control--Heat Transfer

OBJECTIVE AND SIGNIFICANCE

To evaluate the effects of a change in absorptivity and emissivity for spacecraft and radiator surfaces as related to thermal control design.

MEASUREMENTS AND OBSERVATIONS

Temperature	Absorbtivity/emissivity
Time	Reflective index
Effectiveness	Visual observation
Surface finish	

EXPERIMENT DURATION

Intermittently during life of space station.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens (sample carrier)	Baseline EC/LS
Infrared spectrophotometer	Chemical laboratory
Cine/still cameras	Work bench and tools
Integrating reflectometer	Temperature sensor

SPECIAL REQUIREMENTS/REMARKS

Periodic emittances, absorbances, and reflectance tests must be made on samples that have been exposed to the space environment. The degree of changes in absorptivity and emissivity must be determined. In addition, visual observations, surface measurements, and chemical analyses can be made so that changes in α and ϵ may be correlated to both physical and/or chemical variations. Spacecraft radiator and normal surfaces can be used for part of the test. Additionally, small test specimens can be designed with a variety of surface coatings and finishes.

PERSONNEL REQUIRED

1 crew member

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

Descriptive Titles of Experiments Selected by Langley Research Center. 15 November 1963.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-49

Pool Boiling in Long-Term Zero-G

EXPERIMENT CATEGORY

Thermal Control/Water Management--Heat Transfer and Liquid/Gas Behavior

OBJECTIVE AND SIGNIFICANCE

To gain insight into bubble growth rate, the interaction of growing bubbles, the hydrodynamic stability of bubble columns, and nucleation processes.

MEASUREMENTS AND OBSERVATIONS

Pressure
Temperature
Power level
Heat transfer rate

EXPERIMENT DURATION

1 hour for each of 20 tests.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Transport container
Baseline EC/LS (heat source)
Pressure sensor
Shadowgraph
Watt meter
Cine/still cameras
Temperature sensor

SPECIAL REQUIREMENTS/REMARKS

Observations would be made of the growth histories of isolated bubbles, the interaction of bubbles and the thickness history of the thermal layer. The heat flux and local thermodynamic state of the fluid would also be studied. Boiling phenomena are encountered in numerous applications in spacecraft, and a better understanding of zero-g boiling is important. For example, thermal control water boiler design is directly effected by this phenomenon.

PERSONNEL REQUIRED

1 crew member

REFERENCES

NASA Experiment Descriptions for Extended Apollo Earth Orbit Flights, 15 March 1965.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-50

Effect of Wall Temperature, Ventilation Rate, Cabin Pressure, Gas Composition, and Crew Clothing on Comfort Level

EXPERIMENT CATEGORY

Thermal Control/Protective System--Crew Comfort

OBJECTIVE AND SIGNIFICANCE

To obtain comfort criteria for spacecraft operation and the resulting effect on fan and pumping power.

MEASUREMENTS AND OBSERVATIONS

- Temperatures
- Pressure
- Comfort criteria
- Gas velocity
- Humidity
- Gas composition
- Metabolic rate
- Power level

EXPERIMENT DURATION

5 hours for each test condition. (Several hundred test conditions may be evaluated.)

SUBJECTS, MATERIALS, AND EQUIPMENT

- Test specimens
- Baseline EC/LS (atmosphere supply)
- Pressure sensor
- Humidity sensor
- Gas chromotograph
- Ergometer
- Velocity meter
- Comfort simulator
- Zero-g scale
- Temperature sensor
- Cine/still cameras
- Timer
- Metabolic measuring device
- Watt meter
- Flow meter
- Biomedical monitoring equipment
- Dew-point meter
- Special clothing/space suits

SPECIAL REQUIREMENTS/REMARKS

Comfort zone refers to the combination of pressure, atmosphere, wall temperature, gas velocity, and humidity that creates a comfortable environment for the crew. Heat transfer is the major parameter resulting from these variables, and it will be different at zero g than at 1 g because of the lack of free convection at zero g.

PERSONNEL REQUIRED

4 crew members for each test condition

REFERENCES

Engineering Criteria for Spacecraft Cabin Atmosphere Selection. Douglas Report No. DAC-59169 (Contract No. NAS2-1371), November 1966.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-51

Condensing Heat Transfer and Condensation Rate in Heat Exchangers

EXPERIMENT CATEGORY

Thermal Control/Water Management--Condensation

OBJECTIVE AND SIGNIFICANCE

To evaluate heat transfer and water separation in heat exchangers/condensers at low g in order to provide test information needed for adequate design.

MEASUREMENTS AND OBSERVATIONS

Heat transfer effectiveness	Time
Water removal rate	Orientation
Temperature	Gas-generation rate
Humidity	Velocity/velocity profile
Flow rate	Density

EXPERIMENT DURATION

4 hours for each test; repeat 20 times.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens	Baseline EC/LS
Flow meter	Watt meter
Gas liquid separator	Humidity sensor
Pressure sensor	Dew-point meter
Timer	Zero-g scale
Pumps, fans, and blowers	Cine camera
Temperature sensor	Orientation device

SPECIAL REQUIREMENTS/REMARKS

The performance of a heat exchanger/condenser is a function of liquid film thickness on the heat transfer surfaces and the method by which the water is removed from the heat exchanger.

PERSONNEL REQUIRED

1 crew member

REFERENCES

Final Technical Report Study of Zero Gravity Capabilities of Life Support System Components and Processes. Convair Division of General Dynamics Report No. GDC-DBD67-004, February 1968.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-52

Transport of Liquids by Gas Drag

EXPERIMENT CATEGORY

Thermal Control/Water and Waste Management--Liquid Transport by Gas Drag

OBJECTIVE AND SIGNIFICANCE

To obtain zero-g data on the performance of the transport of liquids by gas drag using the thermal control and waste and water management on board equipment.

MEASUREMENTS AND OBSERVATIONS

Motion characteristics	Pressure
Density	Time
Flow rates	Acceleration
Humidity	Gas velocity
Temperature	Friction/drag

EXPERIMENT DURATION

200 hours at 8-hour intervals.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens with blower	Liquid container
Cine camera	Timer
Reference background grid	Zero-g scale
Pressure sensor	Electron microscope
Temperature sensor	Humidity sensor
Work bench and tools	Baseline EC/LS
Flow meter	Dew-point meter
Velocity meter	Gas-liquid separator

SPECIAL REQUIREMENTS/REMARKS

Transport of free liquid droplets by gas drag is involved in water/gas separation after condensation and urine/gas separation and direction control of the liquids. The test specimens can be placed in a by-pass loop within the normal EC/LS system.

PERSONNEL REQUIRED

1 crew member

REFERENCES

Final Technical Report Study of Zero Gravity Capabilities of Life Support System Components and Processes. Convair Division of General Dynamics Report No. GDC-DBD67-004, February 1968.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-53

Water Recovery System Pretreatment Mixing

EXPERIMENT CATEGORY

Water Management--Liquid and Liquid Mixing

OBJECTIVE AND SIGNIFICANCE

To determine if a mixing device is necessary for water recovery unit pretreatment devices.

MEASUREMENTS AND OBSERVATIONS

Diffusion rates
Electrical conductivity
Chemical analysis of liquid
Time
Efficiency

EXPERIMENT DURATION

30 days. (Analyze liquid, mix intermittently as required.)

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Diffusion columns
Chemical laboratory
Liquid container
Stirring unit
Timer
Pretreatment unit
Baseline EC/LS

SPECIAL REQUIREMENTS/REMARKS

Recovery of potable water from urine generally requires the use of pretreatment chemical such as chromic or sulphuric acid. In the absense of gravity, simple diffusion may not be sufficiently rapid to provide proper mixing. Shaking or positive motion may be required to obtain desired results. The test can be performed within the on-board EC/LS system.

PERSONNEL REQUIRED

1 crew member

REFERENCES

Final Technical Report Study of Zero Gravity Capabilities of Life Support System Components and Processes. Convair Division of General Dynamics Report No. GDC-DBD67-004, February 1968.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-54

Composition Mixing and Heat Transfer

EXPERIMENT CATEGORY

Crew Protection--Fire Prevention

OBJECTIVE AND SIGNIFICANCE

To evaluate composition mixing and heat transfer of flames to permit a better understanding of control requirements.

MEASUREMENTS AND OBSERVATIONS

- Pressure
- Gas velocity
- Power level
- Gas composition
- Ignition time
- Thermal radiation
- Total energy
- Chemical contaminants
- Contaminant level
- Heat transfer rate/heat balance

EXPERIMENT DURATION

4 hours for each experiment.

SUBJECTS, MATERIALS, AND EQUIPMENT

- Test specimens
- Fans
- Humidity sensor
- Pressure sensor
- Watt meter
- Timer
- Cine camera
- Optical pyrometer
- Baseline EC/LS (atmosphere supply source and gas analyzer)
- Gas chromatograph
- Infrared spectrophotometer
- Temperature sensor

SPECIAL REQUIREMENTS/REMARKS

Flame control is generally accomplished by limiting the introduction of combustibles and/or heat removal which forces a reduction of flame temperature. The gravity-sensitive processes generally are natural convection, which tends to provide necessary oxygen; and blanketing by a smothering gas or other material. In zero g, with natural convection absent, control of flames should be enhanced, but the smothering effectiveness of a heavy gas or blanket may be markedly reduced.

PERSONNEL REQUIRED

2 crew members

REFERENCES

Final Technical Report Study of Zero Gravity Capabilities of Life Support System Components and Processes. Convair Division of General Dynamics Report No. GDC-DBD67-004, February 1968.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-55

Solids and Fluids Combustion

EXPERIMENT CATEGORY

Crew Protection--Fire Prevention

OBJECTIVE AND SIGNIFICANCE

To determine the propagation of a flame front and the rate of propagation of the flame in a zero-g or low-g environment with various atmospheric compositions and pressures, and an extinguish technique applicable to each or all types of fires.

MEASUREMENTS AND OBSERVATIONS

Pressure	Total energy
Temperature	Chemical contaminants
Gas composition	Contaminant level
Ignition time	Heat transfer rate/heat balance
Burning rate	Volts
Thermal radiation	Amps

EXPERIMENT DURATION

4 hours for each experiment.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens	Humidity sensor
Pressure sensor	Watt meter
Temperature sensor	Volt meter
Baseline EC/LS (atmosphere supply)	Amp meter
Fire extinguishing agents	Chemical laboratory
Cine camera	Fire detector
Timer	Ignition device
Optical pyrometer	

SPECIAL REQUIREMENTS/REMARKS

These tests could include materials to represent all classes of fires.

PERSONNEL REQUIRED

2 crew members

REFERENCES

Report on the Development of the Manned Orbital Research Laboratory (MORL): System Utilization Potential, Analysis of Space Related Objectives. Douglas Report No. SM-48808, September 1965.

Descriptive Titles of Experiments Selected by Langley Research Center. 15 November 1963.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — **TEXT REF. NO. 4-56**

Retention Techniques for Liquids and Solids during Equipment Servicing, Repair, and Maintenance

EXPERIMENT CATEGORY

All Life Support--Solid and Liquid Retention

OBJECTIVE AND SIGNIFICANCE

To evaluate devices and techniques for the retention of solids and liquids.

MEASUREMENTS AND OBSERVATIONS

Subjective opinion of retention technique by crewmen.

EXPERIMENT DURATION

30 min. for each of 80 tests.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Baseline EC/LS
Cine camera
Chemical laboratory
Microbial laboratory
Debris/disposal container
Carbon bag
Plumbing purge unit
Vacuum cleaner
Porous plate water separator

SPECIAL REQUIREMENTS/REMARKS

Liquid retention in plumbing or equipment during manually controlled servicing operations will require special zero-g procedures. The handling of solids, wastes, or mixtures will also require new retention techniques. The experiment can be conducted with the normal on-board EC/LS hardware.

PERSONNEL REQUIRED

Undetermined

REFERENCES

Final Technical Report Study of Zero Gravity Capabilities of Life Support System Components and Processes. Convair Division of General Dynamics Report No. GDC-DBD67-004, February 1968.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-57

Manual Transport of Solids

EXPERIMENT CATEGORY

All Life Support--Solid Transport

OBJECTIVE AND SIGNIFICANCE

To evaluate devices and techniques for the manual transport of solids.

MEASUREMENTS AND OBSERVATIONS

Subjective opinion of crewmen

EXPERIMENT DURATION

Intermittently for 30 days.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Transport container
Vacuum cleaner
Baseline EC/LS
Cine/still cameras
Debris disposal/container

SPECIAL REQUIREMENTS/REMARKS

Feces transfer from the waste management bowl to the drier and then to the storage containers involves solid transport by the crew. Another example is the recovery of solid waste from the atmosphere. In the absence of gravity, loss of the material during transport or opening/closing of containers is a hazard for which handling methods should be evaluated in zero-g. This can be performed as a part of the normal space station housekeeping.

PERSONNEL REQUIRED

1 crew member

REFERENCES

Final Technical Report Study of Zero Gravity Capabilities of Life Support System Components and Processes. Convair Division of General Dynamics Report No. GDC-DBD67-004, February 1968.

EXPERIMENT REQUIREMENTS SUMMARY

EXPERIMENT TITLE — TEXT REF. NO. 4-58

Spillage Recovery and/or Cleanup

EXPERIMENT CATEGORY

All Life Support--Liquid and Solid Recovery and Retention

OBJECTIVE AND SIGNIFICANCE

To evaluate devices for recovering liquids and solids that have escaped into the atmosphere and for controlling the debris.

MEASUREMENTS AND OBSERVATIONS

Subjective opinion of crewmen
Power level
Pressure

EXPERIMENT DURATION

30 min. for each of 10 tests.

SUBJECTS, MATERIALS, AND EQUIPMENT

Test specimens
Cine/still
Flow meter
Pressure sensor
Vacuum cleaner
Watt meter
Baseline EC/LS
Work bench and tools

SPECIAL REQUIREMENTS/REMARKS

None

PERSONNEL REQUIRED

1 crew member

REFERENCES

Final Technical Report Study of Zero Gravity Capabilities of Life Support System Components and Processes. Convair Division of General Dynamics Report No. GDC-DBD67-004, February 1968.